CALIFORNIA SEWAGE WORKS JOURNAL

Official Publication of the California Sewage Works Association

Vol. XII :: 1940 :: No. 2

Minutes of Twelfth Annual Spring Conference
At Avalon, California, May 20, 21, 1940

★

Sewerage and Sewer Maintenance
Ancient Modern

★

Laboratory Tests for Plant Operators

★

Safe Electrical Equipment at Sewage Plants

★

The Sewage Situation at Los Angeles
Los Angeles Pilot Plant

★

Covina Treatment Plant

★

Operation Care of Motor Bearings



NEW SEWAGE PLANT GETS HIGH DEGREE OF PURIFICATION AT COVINA

Uses Chemical Treatment with Bear Brand Chlorine and Ferric Chloride.

A CLEAR, STERILE EFFLUENT is essential in this new 0.5 m. g. d. plant at Covina, California. It is surrounded by an orange grove, in close proximity to homes and wells supplying domestic water. Placed in operation in May, 1939, the new plant has consistently met this high requirement, using Bear Brand Chlorine and Ferric Chloride in the treatment process. Koebig and Koebig, Consulting Engineers of Los Angeles, designed the plant.

Effluent from the two-stage trickling filters is coagulated with ferric chloride, settled, and passed through rapid sand filters. It is then chlorinated and used as irrigation water.

The spent chemical sludge is returned to the incoming raw sewage to deodorize and assist sedimentation in the first settling stage. Ferrous chloride manufactured at the plant is also used as a deodorizing agent.

All sludge is passed through a two-stage digester and when dried on sand beds is used as fertilizer.

Chemical treatment offers economy, high efficiency and simplicity of operation, in new or existing plants. *Your* community may be able to benefit from its application.

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GREAT WESTERN DIVISION

THE DOW CHEMICAL COMPANY

9 MAIN STREET, SAN FRANCISCO
PLANT: PITTSBURG, CALIFORNIA
4151 BANDINI BLVD., LOS ANGELES

GREAT WESTERN DIVISION
BEAR BRAND PRODUCTS
THE DOW CHEMICAL COMPANY

Acknowledgment

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California Sewage Works Journal

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TWELFTH ANNUAL SPRING MEETING

SANTA CATALINA ISLAND

MAY 19-20-21, 1940

PROGRAM

SUNDAY, MAY 19, 1940

Steamer leaves Catalina Dock, Wilmington, at 10 A. M., arriving at the Island at Noon. Registration: 2 to 3 P. M.

Committee Meetings

Golf Tournament — Sightseeing — Recreation

8 to 9 P. M.—Movie Films, Mirror Room, St. Catherine Hotel:

"A Trip Through a Modern Electric Manufacturing Plant"

"The Columbus Sewage Treatment Plant"

Courtesy of General Electric

MONDAY, MAY 20, 1940

7:30 A. M.—Directors' Breakfast, St. Catherine Hotel

Operators' Breakfast, John's Cafe

William A. Allen, Chairman

8 to 9 A. M.—Registration

9 to 9:30 A. M.—Business Meeting, Committee Reports

9:30 to Noon—Technical Papers

Mirror Room, St. Catherine Hotel

"A History of The Sewage Situation Ancient and Modern" (Slides)

Harold F. Gray

"Methods and Problems of Sewer Maintenance, City of Los Angeles" (Slides)

Reuben F. Brown

Discussion . . . Fred D. Bowlus

"Laboratory Tests for The Swage Plant Operator"

Richard Pomeroy

— Noon —

1:45 to 2:00 P. M.—Business Meeting

"Electrical Equipment in Sewage Pumping and Treatment Plants"
Frank A. Short, Engineer State Industrial Accident Commission

"The Sewage Situation of the City of Los Angeles" (Slides)
Prof. Franklin Thomas

Discussion . . . Prof. Chas. Gilman Hyde

"Pollution Control Work of The California State Division of Fish and Game"
Paul A. Shaw

"Covina Sewage Treatment Plans" (Slides)
Adolph F. Koebig, Jr.

Discussion . . . Ray F. Goudy

QUESTIONS

7:30 P. M.—Banquet, St. Catherine Hotel Mirror Room

Guest Speaker—Dean W. Ballentine Henley
University of Southern California

TUESDAY, MAY 21, 1940

9 A. M. to Noon—Technical Papers

"The Maintenance of Sanitary Sewers in San Diego, California"
B. D. Phelps

Discussion . . . Carl M. Hoskinson

SYMPOSIUM

Brief Talks by Plant Operators:

A. E. Fiscus — R. D. Woodward
C. F. Tennant — Verner C. Johnson
Harold L. May

"Experiments Conducted at the Los Angeles City Pilot Plant" (Slides)
H. G. Smith — E. G. Studley

Discussion . . . E. M. Kelly

"The Care of Motor Bearings"
L. M. Best, General Electric Company

Noon — Closing

4:15 P. M.—Steamr leaves for Wilmington

LADIES' ENTERTAINMENT

Monday at 1 P. M. there will be a luncheon for the Ladies at the St. Catherine, followed by bridge.

ANNOUNCEMENT

Dear Member:

The Thirteenth Annual Fall Convention of the California Sewage Works Association will be held at San Diego, California in the U. S. Grant Hotel on September 16-17.

A program is being arranged to meet the interests of Operators, Public Health officials, City Engineers, Consulting Engineers, and Councilmen.

Operator's discussion, Sewer Legislation, Research, Wastes, and Sewer Maintenance are among the topics selected for your ears.

As is our custom, a guest speaker will be heard at the Annual Banquet on some subject of general interest.

May I urge that you start making your plans now to bring the family to San Diego. The Local Arrangements Committee will make them welcome.

Cordially yours,

H. G. SMITH, *President,*
California Sewage Works Association.

TWELFTH ANNUAL SPRING CONFERENCE
CALIFORNIA SEWAGE WORKS ASSOCIATION

Avalon, California, May 20, 21, 1940

MINUTES OF THE MEETING

Monday, May 20, 1940

President Harold G. Smith called the Meeting to order promptly at 9:00 A. M. A short introductory speech called attention of the 93 members and guests present to the charm of the meeting place, Catalina Island, and bid those present welcome.

As there was a full program, the business meeting proceeded rapidly. A report of the Award Committee was presented by Albert J. Castro Jr. The report is published in the California Sewage Works Journal.

Richard Pomeroy presented a progress report of the Fact Finding Committee on Design-Standards. He stated in essence that investigation made by the Committee had revealed a woeful lack of information available at the plants and offered the recommendation of the Committee that the State Board of Health be solicited in an effort to improve plant operation through field equipment and personnel. Acting on the recommendation, the members moved, seconded, and carried by unanimous vote that the Governing Board be instructed to adopt a resolution appropriate to the sense of the recommendation.

The report of the Publicity Committee was read by the secretary. Mr. John A. Clark called attention to publicity in WATER WORKS AND SEWERAGE, WESTERN CONSTRUCTION NEWS, and WESTERN CITY, as well as 75 column inches devoted to activities of the Association at Oakland, September 18-19, 1939.

William A. Allen reported on the Operators' Breakfast. Eighteen members attended and 12 were directly connected with plant operation. Withdrawal of sludge from Primary Sedimentation Tanks, Digester Heating and Coil Maintenance, and the Sale of Sludge for Fertilizer received their due in a lively discussion. J. C. Clark exhibited an ingenious gadget for removing the balls from ball-check valves in sludge pumps.

Mr. J. F. Smith reported on finances of the California Sewage Works Journal. He stated that a program of increased advertising in the Journal was being promulgated.

The above reports were accepted and the Business Meeting was adjourned to a later hour.

The technical program began appropriately with an excellent historical paper, "Sewage in Ancient and Medieval Times," by Harold F. Gray, Consulting Engineer. Mr. Gray's paper was accompanied by slides.

Mr. Reuben F. Brown, Assistant Superintendent, Sewer Maintenance, Los Angeles, followed with a supplementary paper, "Methods and Problems

of Sewer Maintenance, City of Los Angeles, California," and also accompanied his paper with slides. Mr. Fred D. Bowlus, Assistant Engineer, L. A. Co. Sanitary District, presented a written discussion of Mr. Brown's paper offering the problems of the Los Angeles County Sanitation District. Mr. A. M. Rawn offered extemporaneous comment on both the paper and the discussion.

Mr. Richard Pomeroy, Research Chemist, offered a thought provoking paper, "Laboratory Tests for The Sewage Plant Operator." A lively discussion participated in by Messrs. A. C. Beyer, Fred Post, H. G. Smith, A. M. Rawn, and J. C. Clark, followed the paper.

The Business Meeting resumed at 11:45. At this time Mr. W. T. Knowlton discussed the Institute of Government to be given at the University of Southern California in June. Mr. Knowlton called attention to the section on Water Supply, Plumbing, and Sanitary Engineering. "Under this heading many subjects of interest to men in the sewage works field are to be given," Mr. Knowlton said. He urged those who found it possible, to attend.

Mr. Jack Kimball gave a brief report of Membership Committee activities. He called particular attention to the many junior engineers who do not share in the activities of the Association. The membership for the year was reported as quite satisfactory with 235 members as of May 1, 1940. Of these 29 were new members. Copies of the Constitution and By-Laws of the Association are to be used by the Committee in contacting possible members according to Mr. Kimball.

President Smith introduced new members of the Association and asked that those guests present be introduced.

After adjournment for lunch, the Business Meeting was reconvened at 2:00 P. M.

Albert J. Castro and A. C. Beyer opened a discussion of the future of the Award of Merit. Mr. A. M. Rawn commented on the Award with the suggestion that the Award be made only to plants that were operating at design capacity. The general opinion seemed to be that the Award was well worth continuing.

President Smith called the technical session for the afternoon at 2:10 P. M. with a most interesting and timely paper, "Electrical Equipment in Sewage Pumping Plants and Treatment Plants," by Mr. Frank A. Short, Engineer, Industrial Accident Commission, State of California.

Franklin B. Thomas, Professor of Civil Engineering, California Institute of Technology, then presented a paper, "The Sewage Situation of the City of Los Angeles." Harold F. Gray read a discussion of Professor Thomas's paper which had been prepared by Professor Charles G. Hyde.

Continuing a line of thought offered at the Twelfth Annual Fall Meeting of the Association, Paul A. Shaw, Pollution Detail, California Division of Fish and Game, presented a paper, "Pollution Control Work of the California State Division of Fish and Game."

Mr. Adolf H. Koebig Jr., Consulting Engineer, asked that his paper, "Covina Sewage Treatment Plant," be presented by Mr. Ted Gregory of his office. Mr. R. F. Goudey enlarged upon the written discussion of Mr. Koebig's paper. Discussion from the floor followed with Messrs. Phelps, Rawn, Pomeroy, and Bowlus participating.

The Meeting adjourned at 5:00 P. M. with the announcement of President Smith that the Banquet would be held in the Mirror Room of the Hotel St. Catherine.

During the evening President Smith called attention to the very fine work accomplished by the Local Arrangements Committee headed by Howard Jewell. Vigorous applause indicated the appreciation of the members.

Dean W. Ballentine Henley, of the University of Southern California, as guest of the Meeting, offered a philosophical and yet practical subject, which he entitled, "Beautiful Mud." The subject was far afield from the technical aspect of the Association, and as such, was thoroughly enjoyed by the audience.

Tuesday, May 21, 1940

The meeting was called to order at 9:15 A. M. and President Smith asked Mr. B. D. Phelps, Assistant City Engineer, City of San Diego, to present, "The Maintenance of Sanitary Sewers in San Diego, California." Carl M. Hoskinson discussed Mr. Phelp's paper.

During the Operators' Symposium, the following subjects were discussed: "Gadgets," by A. E. Fiscus, Terminal Island; "Sludge Beds," Carl Tennant, Los Angeles, Co. Sanitation District; "Experience in Remodeling Mechanical Aerators in Laguna Beach Plant," R. D. Woodward, Laguna Beach; "Sludge Pump Control," Verner C. Johnson, Covina; "Cause, Effect, and Removal of Scum Formation in the Digester at the Palo Alto Treatment Plant," Harold L. May, Palo Alto. Mr. May's discussion was read by Mr. Jack Kimball.

A general discussion followed with Messrs. Pomeroy, Kelly, Rawn, Wirt, Ingram, Knowlton, Towers, and Gray participating.

After a short recess, the illness of Past President Alexander Bell, was reported and a telegram to Mr. Bell was authorized by acclamation.

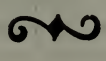
Mr. E. G. Studley, Assistant Civil Engineer, City of Los Angeles presented a paper, "Experiments Conducted at the Los Angeles City Pilot Plant" which had been prepared jointly by Mr. Studley and H. G. Smith, Engineer of Sewer Design, City of Los Angeles. Verbal discussion by J. C. Clark, A. M. Rawn, and Richard Pomeroy followed the paper and Earl M. Kelly offered a written discussion.

President Smith called upon William O. Kyte, of the General Electric Co., to present Mr. L. M. Best of the same company. Mr. Best commented at some length on his written paper, "The Care of Motor Bearings," and answered several questions from the floor in this connection.

The Meeting was closed at 1:15 P. M. by President Smith who expressed his thanks to the group and reminded them that an excellent meeting was in prospect at San Diego, California in September.

Respectfully submitted,

William T. Ingram,
Secretary-Treasurer.



PROGRESS REPORT OF AWARD COMMITTEE

In the first week in April, 1940 the Committee sent to all eligible communities having sewage treatment plants, an announcement of the annual Award of Merit and invited these communities to enter their plant in the competition:

> Each year, the California Sewage Works Association grants an Award of Merit to the Sewage Treatment Plant which, in the opinion of the Committee, has presented the best in sewage treatment with due regard to the treatment facilities available, and to the successful operation of these facilities.
>
> The Committee will receive applications submitted by the certified plant operator of any plant holding an unrevoked permit to operate from the State Board of Health, winners of the past three years excepted.
>
> We feel that your city may have sufficient interest in sewage treatment plant efficiency to offer a report of the activities at your plant. Further details regarding the competition will be sent you on receipt of your favorable reply.

In the last week in May, 1940 we shall send them a second letter, explaining more fully the basis of the Award as well as an application for entrance.

> The California Sewage Works Association again wishes to call your attention to, and invite you to enter your sewage disposal plant in the annual competition for an Award of Merit conducted by this association. There are three awards to be presented:
>
> First: A handsome metal placque presented to the City and twenty-five dollars in cash presented to the chief operator of the plant judged best.
>
> Second: A certificate of merit to the City and fifteen dollars in cash to the operator.
>
> Third: A certificate of merit to the City and ten dollars in cash to the operator.
>
> The purpose in making these annual awards is to stimulate community interest in sewage disposal facilities and to encourage efficient operation.
>
> All plants within the State of California that reasonably meet the requirements of the treatment process employed, hold an unrevoked permit to operate from the State Board of Health, and have an operator certified by the appropriate committee of the C. S. W. A. are eligible to compete for the award, excepting, however, those plants which have received the first award within the immediate past three years.
>
> The Committee on Awards will judge the plant and operator generally in light of the following three considerations:
>
> (a) Intelligent and conscientious operation.
> (b) Appearance of plant.
> (c) Local support, interest, and pride of plant.
>
> To enter this competition the enclosed declaration of entrance should be returned as soon as possible so that the Committee can lend assistance and advice to the operator of the competing plant, if necessary,

in the preparation of a report covering one year or more of operation, together with evidence substantiating his statements, all of which must be submitted on or before September 1, 1940.

The award will be made at the Annual Fall Conference of the C. S. W. A. The operator of the plant or someone representing the plant should be present at the aforementioned conference.

The committee suggests the following as a typical outline for a brief report:

(1) Population and industries served.
(2) Design capacity of plant.
(3) Type and features of plant.
(4) Operating staff.
(5) Records kept.
(6) Laboratory control.
(7) Operating result of various units. (Include effects of trade wastes, if any, on their operation).
(8) Maintenance and operation costs.
(9) Beautification of plant.
(10) Civic interest.

Thus far the Committee has received only two applications.

ALBERT J. CASTRO, JR.,
Chairman.

REPORT OF THE PUBLICITY COMMITTEE

Your publicity committee composed of Mr. F. Wayland Jones, Stockton; Mr. B. D. Phelps, San Diego; and Mr. John A. Clark, Chairman, Berkeley respectfully submit this our report.

We have been unable to get together at any time an order to pool our thoughts upon the publicity for our association. It was the thought of the Chairman in asking Mr. Jones and Mr. Phelps to work with him upon this committee that Mr. Jones would be of assistance in publicizing the activities of the San Joaquin Valley Group, whereas Mr. Phelps would be of great assistance in contacting the local papers in San Diego at the time of our Fall Convention, and in securing as much publicity as possible for the organization during our meetings there.

For this Twelfth Annual Spring Conference your committee has secured publicity in Water Works and Sewerage the Western Construction News and Western City. We have also sent out "Copy" for release about May 16th to the following newspapers:

"CATALINA ISLANDER"	440 words
"LOS ANGELES TIMES"	190 words
"LOS ANGELES EXAMINER"	150 words
"SAN DIEGO UNION"	230 words
"COVINA ARGUS"	180 words
"COVINA CITIZEN"	190 words

We hope and expect that these stories will be published at least in part, however we will have to wait until the next convention to make a definite report of the publicity given this conference.

During the convention held in Oakland last fall we had splendid co-operation from all the Bay Region Newspapers. There were some seventy-five column inches devoted to our activities, and perhaps more which we did not happen to see and collect for the scrap book.

Respectfully submitted,

JOHN A. CLARK,
Chairman.

OPERATORS' BREAKFAST

CATALINA ISLAND

May 20, 1940

The breakfast was attended by 18 members of the California Sewage Works Association of which 12 were directly connected with the operation of treatment plants or sewer systems.

Wm. A. Allen of Pasadena, Chairman of the meeting, gave a brief resume of the previous meeting and indicated the subjects to be discussed. The first subject of discussion was "Withdrawal of Sludge from Primary Sedimentation Tanks." Discussion of this subject was led by Ben Benas, San Francisco, who related experiences and procedure found necessary for sates factory operation stating that he believed there was a decided relation between sludge withdrawal and quality of efficient. V. C. Johnson, Covina, explained that withdrawal of sludge at his plant was regulated by electric time clock operated by the flight mechanism resulting in short periods of pumping at frequent intervals. A. E. Fiscus, Los Angeles, states that they governed sludge withdrawal by the depth of sludge blanket, maintaining approximately 18 inches. R. D. Woodward, Laguna Beach, stated that the rate of withdrawal was regulated by time clock. J. B. Wirt, San Leandro, pumps sludge twice daily with no difficulty from sludge rising to surface of tank.

Difficulties experienced by R. D. Woodward in emptying a digester to replace heater coils opened discussion on the subject of sludge withdrawal from digester and problem connected with digester heating and coil maintenance. This discussion was participated in by V. C. Johnson, A. E. Fiscus, E. G. Studley, Los Angeles, Jack H. Kimball, Palo Alto, R. D. Woodward, J. C. Clark and A. Perry Banta of Los Angeles Co. Sanitary District.

J. C. Clark exhibited the gadget he made for removing balls from ball check valves used with sludge pumps.

The question of whether the sale of digested sludge required a fertilizer manufacturers license was discussed. The general opinion inclined to the belief that this was not necessary, however, it was stated that those interested could obtain a decision from Dr. Alvin J. Cox, Director, State Dept. of Agriculture.

ATTENDANCE

TWELFTH ANNUAL SPRING CONFERENCE

Avalon, California

May 20-21, 1940

Name—	*City—*
Mr. & Mrs. Henry C. Peirson	Los Angeles
Ben Benas	San Francisco
J. B. Wirt	San Leandro
Phil. J. Martin, Jr.,	Tucson, Arizona
William A. Allen	Pasadena
W. O. Kyte	Los Angeles
A. P. Collins	Los Angeles
C. L. Towers	Los Angeles
Fred W. Post	Lodi
Robert G. Harding	Salt Lake City
R. D. Woodward	Laguna Beach
Paul A. Shaw	San Francisco
J. A. Harmon	Los Angeles
Mrs. J. A. Harmon	Los Angeles
William T .Ingram	Stockton
H. G. Smith	Los Angeles
A. B. Shearer	San Anselmo
Mrs. A. B. Shearer	San Anselmo
Reuben W. Borough	Los Angeles
L. S. Curfew	Compton
W. R. Updegraff	Los Angeles
Mrs. Updegraff	Los Angeles
A. M. Rawn	Los Angeles
Harold F. Gray	Berkeley
J. F. Smith	San Francisco
Mrs. J. F. Smith	San Francisco
Fred D. Bowlus	Los Angeles
H. R. Palmer	Los Angeles
Arthur G. Pickett	San Marino
W. T. Knowlton	Los Angeles
Mrs. L. S. Curfew	Compton
Mr. and Mrs. A. L. Frick, Jr.,	Los Angeles
F. C. Horton	Los Angeles
Mr. and Mrs. Bard Livingstone	San Bernardino
E. G. Studley	Los Angeles
G. Kjellburg	Riverside
Mrs. E. F. Kjellburg	Riverside
Ed R. Waggoner	Los Angeles
Adolf H. Koebig	Los Angeles
N. A. Huth	Visalia
Mrs. N. A. Huth	Visalia
Grover L. Walters	Fullerton
W. M. Muckenthaler	Fullerton
Carl Bowen	Fullerton
Wm. H. Montague	Fullerton
H. H. Kohlenberger	Fullerton
J. R. Lester Boyle	Laguna Beach
Mrs. J. R. Lester Boyle	Laguna Beach
Mr. and Mrs. Verner C. Johnson,	Covina
John A. Koch (Guest)	Councilman Covina
Mrs. R. E. White	Bakersfield
Mrs. R. White	Bakersfield
Lawrence H. Cook	Menlo Park
Mrs. Lawrence H. Cook	Menlo Park
Carl M. Hoskinson	Sacramento
R. E. Mittelstaedt	Sacramento
Fred J. Klaus	Sacramento
D. R. Kennedy	Long Beach
A. C. Beyer	San Francisco
R. F. Goudey	Los Angeles
Earl M. Kelly	Los Angeles
Jack H. Kimball	Palo Alto
Mrs. Jack H. Kimball	Palo Alto
Clara K. Shearer	San Anselmo
Helen Shearer	San Anselmo
Albert Castro	Santa Clara
A. Perry Banta	Pasadena
Carl F. Tennant	Long Beach
Elmer B. Belt	San Diego
B. D. Phelps	San Diego
Geo. E. Baled	Long Beach
Richard Pomeroy	Harbor City
Mrs. Richard Pomeroy	Harbor City
Ted Gregory	Temple City
H. H. MacDonald (Guest)	Los Angeles
A. E. Del Pra	U. S. Coast Guard
C. E. Garm (Guest)	Oildale
Mrs. Ella Garm (Guest)	Oildale
Mrs Mabel Roy (Guest)	Oildale
Mrs. Elisie Clark (Guest)	Oildale
Frank Carlton (Guest)	Los Angeles
Reuben F. Brown	Los Angeles
F. A. Short	Los Angeles
A. H. Hanapel	Corona
C. F. Alexander	Corona
L. M. Best	Los Angeles
Geo. Shipe	Santa Ana
H. M. Neighbour	Santa Ana
C. D. Pierce	Los Angeles
John D. McMillan	Newport Beach
Frank Currie	San Bernardino
Franklin Thomas	Pasadena

SEWERAGE IN ANCIENT AND MEDIAEVAL TIMES

By HAROLD FARNSWORTH GRAY, M.S., GR. P.H.,

Member, American Society of Civil Engineers

We frequently hear people speak of "modern sanitation" as if it were something rather recently developed. And there appears to be a prevalent idea that municipal sewerage is a very modern thing that began some time about the middle of the last century. Perhaps these ideas do something to bolster up a somewhat wobbly pride in modern civilization (concerning the inherent values of which some have their doubts), but when examined in the light of history these ideas are seen to be far from new or even recent. Indeed, in the light of history it is a matter of astonishment, if not chagrin, that man in this respect has progressed so very little, if at all, in some four thousand years.

Some of you may remember something of the Mesopotamian Empires of Assyria, Babylonia, and their antecedent Sumerian and Akkadian states, which were great advances in civilization for their times. An example is the city of Eshnunna, located about 50 miles northeast of the present Baghdad. The ruins of Eshnunna have been excavated by the Oriental Institute of the University of Chicago, exposing sewers constructed of brick, with laterals connecting to water-flushed latrines in the houses. Eshnunna is dated about 2500 B. C., or about the reign of Sargon I. But archeological researches in the past twenty or thirty years have yielded a considerable amount of information concerning other communities either contemporary with, or antedating the Assyrians and the Babylonians. In these other communities the art of sanitation had reached a development which might even shame some of our modern towns of similar size. At least as to be worth a brief examination. They are the Indus civilization of about 2550 B. C., and probably much earlier, and the Aegean civilization of about 3400-1200 B. C.

The Indus civilization is best known through the excavation of Mohenjo-daro, "The Mound of the Dead," which is located in Sind, about 25 miles from Larkana town, and almost due north from Hyderabad about 130 miles. A similar and larger ruin, Harappa, is located some 400 miles northeast of Mohenjo-daro, and in this general area between Mohenjo-daro and Harappa there are numerous mounds indicating other cities of this same Indus culture, and in addition there are mounds of an even earlier and distinct Amri culture.

The upper levels of Mohenjo-daro are dated about 2550 B. C. The lower levels probably go back much further, but high ground water has prevented effective excavation into these earlier cities. The mounds above the ruins average 20 to 30 feet in height (with a maximum of 70 feet) and cover an area of about 240 acres, but floods and erosion have probably greatly reduced the original extent of the ruins.

These Indus people had a highly developed chalcolithic (stone implements contemporary with copper or bronze) culture which was similar to and in some respects superior to the contemporary Mesopotamian and Egyptian culture. They were organized into cities, with a well developed commerce in all directions. They had wheeled vehicles for transport. They were skilled metal workers, using gold, silver, copper and lead, and tin in bronze. They made cotton into textiles. They had domesticated the dog, pig, sheep,

buffalo, humped zebu, camel and elephant, but probably not the horse or cat. They had well-built and commodious houses, and baths, with drainage systems built of well-burned brick, and the common people probably enjoyed a degree of comfort unknown in other parts of the world, for in other contemporaneous civilizations the skill of the artist and builder was lavished upon the temples and palaces, but the homes of the ordinary people were apparently inadequate and ephemeral hovels.

Furthermore, the Indus civilization as known by present excavation was already old at 2500 B. C., and was not an incipient civilization, for there are several other levels, one below the other, of earlier cities, and in the lower levels the workmanship appears to be even better than in the uppermost level.

Practically every house in Mohenjo-daro had its bathroom, always placed on the street side of the building for the convenient disposal of waste water into the street drains. Where latrines have been found in the houses, they were placed on the street wall for the same reason. Ablution places were set immediately adjacent to the latrines, thus conforming to one of the most modern of sanitary maxims. Where baths and latrines were located on the upper floor, they were drained usually by vertical terra-cotta pipes with closely fitting spigot joints, set in the building wall.

These ancient terra-cotta pipes, still sound after nearly five thousand years, are the precursor of our modern vitrified clay spigot-and-socket sewer pipe, and are an excellent guarantee of the durability of this material.

Houses also had rubbish chutes built into the walls and descending from the upper floors, at the foot of which chutes there were sometimes provided bins at the street level which could be cleaned out by the scavengers. Public rubbish bins were also provided at convenient places.

The bath and kitchen waters, as well as drainage from the latrines, and the roof drainage, usually did not run into the street drains direct, but entered them via tightly brick-lined pits, with outlets to the street drains about three-quarters of the distance above the bottom. Apparently these pits were cleaned out from time to time, as were the settling basins or soakage pits located along the street drains. These pits may have been the ancient precursors of our present day septic tanks and grit chambers. In some houses the drainage water discharged into large pottery jars placed in the street at the foot of the vertical drains in the street walls.

Each street and lane had one or two drainage channels, with brick or stone covers which could be lifted to remove obstruction in the drains. The drains were usually 18 inches to 24 inches below the street level, and varied in dimensions from 12 inches deep and 9 inches wide to about 24 inches deep and 18 inches wide. When the drain could not be covered by flat bricks, or stone slabs, the roof of the drain was corbelled.

The principal community bath was a structure of considerable size, conforming somewhat with our ideas of a swimming pool, though perhaps being used rather as a place for religious ceremonials than for either mere pleasure or for only the cleansing of the body. The structural features of the pool indicate an excellent ability in construction, considering the building materials available at that time and place. For example, waterproofing was accomplished by a membrane or coating of asphaltum between the inner and outer walls of the pool or tank.

Many of the homes had their individual wells within the buildings. These wells were usually circular in plan, though at times oval, and had copings of stone or brick at the floor level, and brick lining for a moderate depth below the surface. In a few instances the street drains ran rather too close to the wells, and it is possible that some contamination of the well occurred. But in most cases the wells were located at adequate distances from the drains.

Considered as a whole, the Mohenjo-daro ruins present a picture of a community in which both personal and community cleanliness was quite effectively practiced, and the water supply reasonably safeguarded from contamination as a rule.

But lest it be assumed that the prehistoric Indus civilization was a rare and unusual thing, let us examine the nearly contemporaneous and very remarkable civilization which flourished around the Aegean Sea about 3000-1000 B. C. It is shown in its highest development in the ruins of the Palace of Minos near Knossus on the Island of Crete.

The Minoans were builders of splendid palaces of stone; they constructed paved roads and viaducts; they had developed a high degree of art in frescoes, in statuary and bas-reliefs, in decorated pottery, and in medallions. Their gold and silver work was of a high order, they were skilled workers in copper and bronze, and they made exceptionally fine textiles. Some of their statuettes, for example the statuette of the snake goddess, are almost startlingly modern in conception and execution.

They had developed a considerable knowledge of hydraulics. They built fountains, which shows that they knew how to carry water in pipes under pressure. Tapered terra-cotta pipes have been found, with spigots, collars and stop ridges, among the earliest elements of the palace. Water for drinking was apparently obtained also in part from wells, many of which were lined with hard terra-cotta liners, each section being one-third of the periphery, and having a slight socket at the top of each ring to fit the bottom of the next upper ring. Their bath tubs were remarkably similar to our modern tubs, and perhaps more artistically decorated.

Particularly in the Middle Minoan Period, dated about 1900-1700 B. C., elaborate systems of well built stone drains were constructed, which carried sewage, roof water and general drainage. The main drain transported these wastes a considerable distance beyond the palace, but we do not know the method of their final disposal.

Each quarter or section of the palace had its own subsidiary drainage system connected to the main drain. These systems had vertical shafts of ample size which acted both as roof drains and as ventilation ducts, the latter in much the same manner as do the soil stacks in our modern houses. The frequent and torrential rains in Crete would result in excellent flushing of the entire drainage system.

Such sanitary arrangements were not particular to the palace at Knossus, but seem to have been an essential part of all Cretan building. A. Mosso, in describing the ruins of the villa of Hagia Triada, makes the following statement:

"One day, after a heavy downpour of rain, I was interested to find that

all the drains acted perfectly, and I saw the water flow from sewers through which a man could walk upright. I doubt if there is any other instance of a drainage system acting after 4,000 years."

Perhaps we also may be permitted to doubt whether *our* modern sewerage systems will still be functioning after even one thousand years.

Latrines were provided within the palace, directly connected to vertical chutes or to horizontal drains. Apparently these latrines were flushed after use by emptying a large jar of water into the latrine. The latrine seat was the edge of a wood plank set vertically into recessed slots in the side walls, with the rear wall as a back rest, which was effective but perhaps not quite so comfortable as our modern split-front seats of plastic.

Rubbish was apparently placed in a number of circular walled pits, about 5 meters in diameter, which were probably cleaned out from time to time as necessary.

All in all, the archeological researches on this site yield a picture of a people who had progressed far along the path of comfortable and hygienic living, with a considerable degree of beauty and luxury in their surroundings. And this had been accomplished some four thousand years ago.

All are familiar with the high degree of sanitation achieved by the Romans, but certain rather commonly held errors need correction. For example, the so-called sewers of Rome, of which the Cloaca maxima is the best known, were primarily conduit for the removal of surface drainage (rain water) and underground water. They were not designed as sewers as we understand them today, had few house connections, and were not expected to receive excrement directly. But apparently in ancient Rome excrement and other wastes were thrown into the streets, and thence flushed into the drains in the process of street cleaning. One of the complaints of Frontinus, the Roman water commissioner of about 100 A. D., was that so much water was feloniously diverted from the aqueducts, for agricultural irrigation outside of Rome, that there was at times insufficient water for cleaning the streets.

Mediæval and even modern Europeans, so far as sanitation was concerned, were certainly not above the savage level, and even fell below it. In Berlin, the refuse heaps piled up in front of St. Peter's Church until in 1671 a law required every peasant who came to town to remove a load of filth when he returned home.

In 1183, when the Emperor of the Holy Roman Empire held a Diet in the palace of Erfurt, the floor of the main hall broke, precipitating the lords and knights into the cesspool below, where many perished, the Emperor himself barely escaping death.

In Denmark, the cleaning of the latrines was the job of the hangman, who probably did the job very poorly indeed, for in Helsingfor in 1583 a Hollander residing there outraged the community by personally cleaning out his latrine after repeated efforts had failed to induce the town officials to have the job done.

Paris in the Middle Ages was the metropolis of Europe and at least superficially the focus of refinement in living. But the streets were foul with filth. Montaigne complained that he found it difficult to rent lodgings where the reek from the streets did not assault his nose. Parisians freely emptied chamber-pots from their windows, only the nimble and the lucky escaping being drenched. The poorer classes defecated indiscriminately wherever

most convenient. In 1531 a law required landlords to provide a latrine for every house, but it does not appear to have been well enforced. Toward the time of the French Revolution privies were numerous in Paris, but apparently they were so filthy that even the least fastidious preferred other places for easing themselves. A favorite locality was the terrace of the Tuileries, which eventually became so fouled that the superintendent of the royal grounds installed a latrine, charging an admission fee of two sous.

Enraged at the high price, the public removed their excretory affections to the Royal Palace grounds, forcing the Duc d'Orleans to construct a dozen privies, which fortunately were better patronized. But the Louvre was a mess. People defecated without restraint or attempt at secrecy in the courtyards, on the stairs and balconies, and behind doors, without hindrance by the palace attendants. And if the commonalty were guilty of such gross violations of sanitation and decency, they had excellent examples in high places. On August 8, 1606, an order was given prohibiting any resident of the palace of Saint Germain from committing a nuisance therein. That same day the King's son urinated against the wall of his room.

The disposal of excrement in mediæval England presented problems which the Englishman of that day tried to solve in various ways, most of them much inferior to the methods developed nearly three thousand years prior in Crete. Little is known of the methods used by the agricultural population; it was probably quite casual. The wealthy lords built several types for their castles. Where there was running water in the moat, garderboes or latrines were sometimes corbelled out over the moat from the face of the exterior wall, so that the dejecta had a fairly clear drop into the moat. However, in the winter this arrangement was probably cold and drafty, and no doubt the enterior wall was rather well plastered with excrement. In other instances chutes were built into walls, or in separate turrents, and water diverted through the base of the chute. However, this was apt to result in bad odors due to fouling of the sides of the chutes.

Where running water was not available for carrying away the excrement falling into it, pits or cesspools were constructed, frequently of masonry, for storing the excrement received from the floors above via various types of chutes. Chutes were frequently built in the thick walls of chimneys, for warmth, but this undoubtedly added to the odor problem. In other cases the cesspool must have been below the floor, for according to the Coroner's Roll of 1326, Richard the Raker, having entered and seated himself, the rotten planks of the floor gave way, and Richard perished most odorously by drowning in the contents of the pit.

In a few cases pipes or channels were built to remove the overflow of the pits, as at Westminster Palace about 1260, but by 1307 this conduit became so blocked with filth that it had to be cleaned out and repaired. However, some of our modern sewers have not lasted forty seven years, wherefore let us not be censorious.

In mediæval London the problem was made more difficult because of overcrowding. Public latrines, with running water for the clearance of the excrement, were known in London prior to 1290. Tenements were usually inadequately provided with latrines; for example, in 1579, in Tower Street in the Parish of All Hallows, there were three privies for eighty-five people. Doubtless even in normal times a considerable amount of excrement was

simply thrown into the streets and lanes, because of the inadequate and malodorous privies; in abnormal times this condition was aggravated, for in the plague year of 1349 the King ordered city authorities to remove the filth accumulated in the streets and most foully polluting the air of the city, although the city was one-third depleted of its population by the plague.

If the Mediæval European was a failure in sanitation, his bad example did little to improve the modern European until the very recent present, and then but partially.

In London, the discharge of any water except kitchen slops into the drains was prohibited by law until 1815, and this regulation persisted in Paris until 1880. In London the report of the Health of Towns Commission in 1844 revealed such astonishing amounts of decomposing excrement and organic matter throughout the English cities that the report aroused a strong movement to improve conditions which had long been intolerable. By 1847 it had been made obligatory by law to discharge excrement into the drains, and the cesspits, pail privies and kitchen middens were gradually abolished. But if the Englishmen's long struggle with excrement disposal made rather slow progress in achieving a satisfactory solution of the problem, it proved highly successful in the production of laughable tales concerning their ineptitudes in this respect, including some hilarious incidents in their novels, for example the inn scene in "Roderick Rodom." Moilere and other French writers used similar materials, though with greater deftness. Indeed, it would be most surprising if such an ever-present factor in daily life failed to be reflected in the literature of the time.

The Englishmen of the last century finally did succeed in divorcing themselves from immediate juxtaposition with their own excrement and the stench thereof, thereby at long last catching up in part with the Minoans of nearly 4000 years previously, but they for a while merely exchanged one problem for another. As early as 1842 the Poor Law Commissioners advised against the discharge of sewage direct into streams which were used for water supply. London, of course, had simply removed its excrement from accumulation of reeking filth in and about the houses, and transferred the entire mess into the Thames River, within the city limits. Nothing was done about it until 1855, when at the end of a disastrous epidemic of Asiatic cholera, (that great blessing of man because it has literally terrified him out of his sanitary apathy and into sanitary improvements) the Nuisance Removal Act was passed, prohibiting gross river pollution. But, in spite of the cholera, for quite a while the interference of gross pollution with the industrial and agricultural uses of water was given more attention than the menace to health. In passing it might be mentioned that London was still to suffer two more great epidemics of cholera, in 1866 and again in 1872, showing how slow human progress was even in the face of the most urgent compulsion.

London, of course, reaped the reward of its bungling attempts to clean up the city by dumping sewage into the river. The years of 1858-59 were the years of the great stink in London. This was vividly described by Dr. William Budd as follows:

"For the first time in the history of man, the sewage of nearly three millions of people had been brought to seethe and ferment under a burning sun, in one vast open cloaca lying in their midst. The result was all know. Stench so foul, we may well believe, had never before ascended to pollute

this lower air. Never before, at least, had a stink risen to the height of an historic event. Even ancient fable failed to furnish figures adequate to convey a conception of its thrice Augean foulness. For many weeks, the atmosphere of Parliamentary Committee-rooms was only rendered barely tolerable by the suspension before every window, of blinds saturated with chloride of lime, and by the lavish use of this and other disinfectants. More than once, in spite of simliar precautions, the law-courts were suddenly broken up by an insupportable invasion of the noxious vapor. The River steamers lost their accustomed traffic, and travellers, pressed for time, often made a circuit of many miles rather than cross one of the city bridges.

"For months together, the topic almost monopolized the public prints. Day after day, week after week, the 'Times' teemed with letters, filled with complaint, prophetic of calamity, or suggesting remedies. Here and there, a more than commonly passionate appeal showed how intensely the evil was felt by those who were condemned to dwell on the Stygian banks. At home and abroad, the state of the chief rivers was felt to be a national reproach. 'India is in revolt, and the Thames stinks,' were the two great facts coupled together by a distinguished foreign writer, to mark the climax of a national humiliation."

And this nearly four thousand years after the prehistoric Cretans! How we did progress!

Our English cousins were not slower nor were they less intelligent than the inhabitants of other European countries. Similar conditions could be described "ad nauseum" in various European cities, and also in some of our own (Bubbly Creek in Chicago), but they were unfortunately not described in Budd's pugent prose. And in passing it may be mentioned that in 1940 we ourselves are performing a very fair job in the creation and maintenance of monumental stinks that would do credit to the most barbarous community. For reasons of at least a moderate delicacy, I refrain from naming names.

Urban man today still unnecessarily pollutes streams, bathing beaches, bays and estuaries, without benefit of the excuse of ignorance which was available to his ancestors.

Sewage works associations, engineering societies and the public health associations are doing good work in enlarging the technical knowledge needed to solve our sanitary problems, but whether they can do much to jolt the sanitary conscience of the average man into really adequate sanitary action still seems to be dubious. We appear at present to be possessed of more technical knowledge than we are permitted to apply, due to the conflict between the immediate dollar of sanitation expenditure versus (to the average man) rather intangible future comforts and benefits.

If our progress today is so much less than what we know is possible, let us not be disheartened. Even though in four thousand years we have accomplished relatively little in sanitation, remember that after all that is but a small sector of time in man's history. He has existed in substantially his present type for at least 150,000 years, during which time he has not abolished or appreciably diminished war, or famine, or pestilence, nor murder, avarice, greed, intolerance, nor economic disasters, nor does it appear to be even probable that he will ever do so, and probably our great-grandchildren's remote descendants will still be struggling with the problem of disposing of their excrement.

METHODS AND PROBLEMS OF SEWER MAINTENANCE

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"Of the various city wastes to be gotten rid of, sewage is the most serious in magnitude and in nuisance producing and death dealing possibilities." *(1)

The proper collection and disposal of sewage ranks next in importance to water supply in the life of any community. *(2)

Sewage is a combination of liquid wastes conducted away from residences, business buildings and institutions together with those from industrial establishments; with such ground, surface and storm water as may be present. The sewerage system consists of pipes and other conduits, appurtenances and works for the collection, treatment or disposal of sewage.

Maintenance methods and problems deal with all matter entering a sewerage system whereby the effluent is effected as it starts its process of changing condition, giving off gases, odor, vapors beneficial and dangerous to human life, or to the steel, concrete, iron or whatever may be used as a carrier for waste matter in its proper treatment and disposal. "Maintenance is the art and science to preserve," *(3) by keeping all structures, pipe lines, pumping plants and disposal plants in first class operating condition. It is this problem of maintenance in which we are interested.

Sanitary Engineers have devoted most of their time to treatment and disposal of sewage, forgetting to some extent that part of the disposal problem begins at the house connection inlet and may develop on its way to the treatment plant.

Maintenance really begins with the Design and Construction of the sewerage system. Thirty years ago this might not have been true as sewer maintenance consisted mostly of "trouble shooting," pipe line stoppages, and when machinery broke down to then replace it while the sewage was by-passed to the most convenient location for disposal. Today, due to the evolution or progress of living conditions, the rapid growth of communities, and the forward stride of sanitation, the closest kind of cooperation is necessary between the Design, Construction and Maintenance Divisions. The results of new methods, new types of construction and changes made necessary thru field conditions should all be reported to be common knowledge of all concerned, so greater efficiency in maintenance may be obtained. "In fact this cooperative and harmonious relations could exist to the point that when sewer bond

issues or sewer appropriations were considered they could be stretched just a little to include new maintenance equipment" or increased personnel per mile of sewer or plant added to the system. *(4)

In order for the above coordination between Divisions to exist there should be "Uniform Sanitation Records." *(5) In years past many employees in all parts of the nation on maintenance work were known for their ability to remember what happened fifteen or twenty years ago with the result that much valuable information was lost. Keeping records on maintenance work should be one of the first items remembered by operators and employees; as the principal concern of public officials, civic associations and tax economy leagues is with the results of the work and its cost.

These records should also show that proper maintenance has been given and equipment operated the way it was designed to function, and at all times be at the disposal of the designing engineers.

Maintenance Work

In the City of Los Angeles, the Sewer Maintenance Division has charge of the maintenance and repair of all sanitary sewers, storm drains, culverts, flush tanks, sewage and storm water pumping plants, ventilating plants and the Hyperion Sewage screening plant, the elimination of storm water from the sanitary sewerage system, the elimination of explosive gas and detrimental industrial waste from both sewers and storm drains and the control and maintenance of open storm water channels. *(6)

The sewer and storm drain system consists of 2,794 miles of sewers and 11,599 flushing structures, 630 miles of storm drains with 26,200 catch basins, 632 culverts, 18 pumping plants, one storm water pumping plant and a sewage screening plant.

The personnel consists of 134 persons subject to twenty-four hours service when necessary, due to emergency work at time of storms, pipe line stoppages or plant failure.

Systematic Maintenance

In this article only one phase of the maintenance work and its cost will be considered and that is Pipe Line Maintenance, in the effort to keep sewers and storm drains clean, sanitary and unobstructed, so that the full efficiency may be obtained for which they were built. "The Preventing and removing of deposits, and the maintaining of ample and safe ventilation." *(7)

This maintenance is the protection given an investment by the citizens over a period of years of about sixty-five million dollars, and serving an estimated population of one million five hundred thousand. (1,500,000 population).

In the planned maintenance program it is essential that systematic inspection and cleaning, and flushing should be done as a preventive measure not waiting until reports of stoppages or breakdowns occur.

The City is divided into approximately 350 sewer districts, each of which has a corresponding map number, which map shows all streets, rights of way, location, size, elevation and grade of sewer, location of manholes and elevation of street surface, etc.

Each of the six yards located in different parts of the City has a copy of these maps for sewers and storm drains, which are given to the crews as

work is assigned in various districts. A monthly record is kept on a key map in the main office when these inspections are made. Thru this systematic inspection the entire sewer system is gone over every six months. Bad sewer locations are recorded and given the necessary maintenance for their proper functioning.

The sewers are constructed to flow by gravity on grades that will give a self cleaning velocity which should be between two and seven feet per second. Experienced personnel are able to determine by inspection when clogging or deposits are occurring and that sewer is then rodded and cleaned and the obstruction removed.

Daily time sheets show work done, time on each class of work and materials used. A monthly recapitulation of time and work is made which on a graph chart shows the division of time spent, or any sudden increase or decrease on various classes of work.

Field Crews and Trucks

Twenty Nine Field Crews, equipped with trucks maintain the sewage system. A crew consists of one foreman and two or three men. These trucks are of 1½ ton canopy type and carry about $500 worth of tools for maintenance work such as 350 feet of all types of sewer rods, 500 feet of 2½ inch fire hose, hooks, cutters, spears, scoops, augers, self-propelling, revolving nozzles, picks, shovels, bars, gads, buckets, lanterns, flash lights, rubber sand cups, mirrors, spot lights with 50 feet of cord, rope, safety belts, hydrant wrenches, rod wrenches, hammers, sledges, small tools, beach balls, etc., with rubber hip boots for each member of the crew. These trucks are equipped with trailer hook for hauling pumps, and five dump trailers are used for catch basin cleaning on light pick ups. Some of the trucks are equipped with 120 volt electric generators which are used to operate electric driven fans for ventilation of manholes and pipe lines that have dangerous gases and obnoxious odors.

These generators also operate an electric drill, hammer or saw and will operate 15 or 20 electric lights for night work or inside pipe work.

All automotive equipment used has been operated on the average of 212,000 miles per year at a cost of about 4 cents per mile. Automotive Control by Oil Analysis is used for truck operation which gives an opportunity to make minor adjustments and repairs before there is a serious breakdown and keep trucks in service without delay. This same control is used on all portable and stationary gas engines.

Cleaning and Rodding

Cleaning and rodding of sewer lines is necessary only when there appears to be a clogging or a stoppage in the line, breakage of pipes and bad odors. This may be caused by deposition of sand, rags, grease discharged hot into line which becomes cool and is deposited in thick layers on the pipe, fungus growth where periodic flushing has been neglected over six months, corrosive acid or chemicals disintegrating cement pipe, tarry and oil deposits from manufacturing plants forming tough greasy masses, gas residue from tanks, steel filings, broken bottles, cement washings, concrete and brick from construction work, improper use of toilets over manholes, soap, lime deposits, and scale from boiler waste and roots. Broken sewers are caused by excessive

super-imposed loads, unsound foundations, undermining and progressive deterioration.

In cleaning, *iron rods* of 5/8" black pipe fitted with special screw couplings with hexagon collars at one end for use of wrench, are used for slow heave hand work. Wooden rods are the regular round standard hickory rod with slip coupling and are used for light fast hand work when slight obstructions appear in the line. Heavy wooden "Jumbo" rods are used mostly on storm drains from the outlet pipe to catch basins. *Flexible Steel Rods* which are manufactured locally have a ratchet wrench attachment that enables the operator to turn the rods as they are pushed into the sewer. They are also provided with guides which enable them to be worked from the surface when manhole is full or partially full of sewage. This is called the cool easy way. *Straight and self propelling nozzles* are used for cutting and can be inserted as much as 300 feet into a sewer. *Beach Balls* that will fit snugly in pipe are inserted into the outlet of an upper manhole and with hydraulic pressure caused by backing up of the sewage around the ball, the accumulated substance is cut ahead of the ball, cleaning the line. Sand traps with 1/4 bend are placed in manhole ahead to catch heavy material washed out. Rubber cups attached to rods are also used for this purpose in the same manner as the beach ball. In large sewers a canvas "kite" attached to a cable has been effectively used. Care should be taken that sewage is not backed up thru the House Connections when cleaning in this manner.

Besides hand cleaning the City has one of the first Werko Power Sewer Sweeps. It is a portable machine which carries about 500 feet of 5/16 inch special oil tempered spring wire wound on a reel, the reel being mounted on a carriage which rotates round on an axis perpendicular to the reel axis with steel fingers meantime feeding the wire out or in thru a curved pipe extending from the machine, through a manhole into the sewer. The forward end of the wire carries any kind of a cutting or cleaning tool desired, revolving it at any speed desired up to 750 R.P.M., and moving it forward and backward at any speed up to 100 feet per minute. The power unit is an eight cylinder gasoline engine. This machine cleaned 413,703 feet of sewer in one year at an average of 254 feet per hour of working day. The cost of this type of heavy work was 3 1/2 cents per foot of sewer cleaned.

Storm drains are systematically maintained the same as sanitary sewers but take a different type of maintenance work. The principal work required is cleaning catch basins and culverts. All large drains are inspected twice a year, in the Fall before the rains and in the spring. Catch Basins and laterals are inspected and cleaned when necessary on a daily, weekly and monthly schedule, depending upon local needs. In pipe large enough to permit a man to work, material is removed by shoveling into bucket or wheeled carrier, moved to manhole, raised to the surface and dumped. The Champion self loading bucket is used where pipe lines are too small for men to work inside, the bucket is on a cable operated by a gasoline engine on the street level above. The cost of the work of cleaning is .305 per catch basin, .017 per foot of culvert and .007 per foot of storm drain.

Construction and Repairs

Maintaining Sewers also includes the necessary construction and repair work. This work is generally more difficult to perform than the original

construction work. On excavating a second time the ground is loose and more difficult to hold and usually saturated with sewage. It is generally of an emergency nature and in the business and congested districts and often has to be done at night. Repairs common to the sewer system are replacing manhole covers, street inlets or catch basins broken by traffic or thru progressive deterioration, raising and lowering of sewer and storm drain manholes and catch basins caused by settling or raising of the pavement and also subsequent fills or cuts in the streets, replacing of broken pipe, replacing loose brick and mortar which has dropped out, repairing of manhole bottoms and plastering of inside to prevent deterioration due to gasses, replacing manhole steps; locating and replacing house connections in city streets, excavating for and laying relief lines to ease overloaded conditions; excavating and opening up lines due to stoppages in line and relaying and cleaning same; tunneling into fills to replace crushed pipe due to settlement or improper reinforcing, storm damage construction and repairs due to flooded conditions, minor repairs and pulling of pumps; and experimental construction.

The cost of this work for one year is as follows:

		Cost Per Mile In Service
Sewer Repairs	$15,224.98	$5.49
Storm Drain Repair . . .	5,557.20	8.82
Sewer Construction . . .	6,408.09	
Storm Drain Construction . .	8,152.98	

Manhole Covers

Constant complaints are received on account of noisy and loose manhole covers. There are about 70,000 manhole covers in the city of all types. Different methods have been used to stop noisy manholes by placing different materials to cushion the covers, some of which are quite costly and have not been very satisfactory. An application of hot tar has given the best results but it has to be renewed from time to time. Locking manhole covers are being specified at the present time but the removing of the cover slows down maintenance inspection. The newspapers have carried notices telling citizens to call and noisy covers will be replaced or repaired. This has increased the number of Noisy Manhole covers sealed. In 1938 there were 2,815 and in 1939 there were 1,833 at an average cost of $2,907.20 for the year or $1.58 each.

Below is a tabulation of our recent maintenance costs:

YEAR 1939

Type of Work	*Work Done*	*Cost*	*Cost Per Mile In Service*
SEWERS			
Sewer Stoppages	95	$ 1,151.10	$.41
Sewer M. H. Cleaned	13,435	4,163.21	1.49
Sewer M. H. Inspected Miles of Sewer Inspected	134,991 6,798	18,044.71	6.46
Miles of Sewer Cleaned	204	14,345.80	5.13
Miles of Sewer Flushed	126	1,464.27	.52

STORM DRAIN

Catch Basins Cleaned	56,479	23,300.69	36.99
Miles Culvert Cleaned	72	1,747.61	12.30
Miles Storm Drain Cleaned	158	6,395.65	10.15
Miles Storm Drain Inspected	137	1,691.83	2.69

The total cost per mile of sewer lines in service for inspection, cleaning and replacing is $20.06. For Storm Drain Maintenance, Inspection and Cleaning and Repairing it is $71.62 per mile in service.

Sewer Flushing

The same systematic inspection used on pipe line is used in the maintenance of the 11,599 flushing structures. The combined method of flushing sewer pipe lines, inspection and cleaning seems to be the best procedure in the City of Los Angeles sewerage system. There seems to be many differences of opinion as to the method of flushing either with automatics, hand flushing, flushing with fire hose or water wagon. All four methods are used as the conditions require because, "sewers must be flushed to remove and prevent deposits, which becoming putrescent would produce noxious and offensive gases and eventually cause choking of the system." *(8) Putrefaction does not set in until after a period of about twenty-four hours; and in a well designed system the sewage should never take a longer time than this to reach the outfall, treatment plant or point of disposal. A sewer that has been laid at a grade that is self cleaning only when running half or one third full, which may not be the normal state of affairs, may need daily flushing to prevent deposits and render the sewer air unobjectionable. "Flushing helps get rid of sulphur compounds which are a considerable factor in causing unusually high H2S readings as proper flushing not only adds water giving the proper velocity for scouring but it sucks in air causing better ventilation." *(9)

At the present time there are six types of automatic flushers used in the City and the regular hand operated flushing manhole. Six field crews of two men each with trucks and one shop crew who recondition equipment with an office clerk and a Foreman maintain all flushing structures in the City. All flushing structures are numbered by the design division when constructed, at which time the type of apparatus is installed as required by the Contractor during construction. Inspection and repairs in the field are made from daily work schedule assigned each crew and a report made showing time spent, work done and materials used on each tank. This is posted on a report card from which the monthly reports are made out. This report card shows the number of the tank, when installed, when inspected, condition found, repairs made, work done, condition left and condition of the water service. Besides the report card there is a card file by number and location and also another card file by location and number of all structures. Work in the field consists of cleaning, renewing of parts, if any, installing or dismantling and plain inspection, or check of condition.

Automatic flushers are installed on flat grades and hand flushing is used on 1.6% grades or more.

Automatic flushers operate daily, dumping 300 gallons of water every twenty-four hours while manual operated flushers are flushed once in from four to six months using 500 gallons of water per flush. Hand flushers are

operated by turning on ten or more tanks, then going back and flushing and shutting the water off when full. Materials removed by flushing is fine sand, course sand, road detritus, ¼" to 2½" broken stone and gravel and whole brick. "This material would form a stoppage unless flushed to the trunk line of the sewer system where the velocity causes continuous suspension and has the required transporting power." *(10)

Water services are maintained inside this tank by the flushing crews on private water companies lines but the Bureau of Water Works and Supply inspects and maintains the service to see that the water jet meter is given the required amount of water on automatic tanks each day on City water lines. Monthly check of Water Department record is made against the report card to get the total amount of water used each month.

Automatic flushers operating at the present time are 6,579. The total number of manually operated tanks in service are 2,483. The cost of operating Automatic flushers of all ages of service from ten years to thirty-two years, is thirty-five cents (35c) per month or $4.20 pear year per structure. The cost of hand flushing per structure is 76c per year.

Gas Survey

Danger lurks under the street. Manholes have blown up, streets have been torn open by explosions, pumping plants have been wrecked by the explosions of gases coming from sewer an storm drain lines. The vital arteries of the modern city are sealed in by gas tight pavements. Underneath this seal, inflammable gases may leak from mains and enter into any portion of the sewer or storm drain structures. Industrial wastes such as crank case oil and such petroleum substances as benzine and gasoline find their way into the sewer from storage and service stations and garages, and probably from dyers and cleaners and other manufacturies, thus creating a gas hazard.

In order to prevent explosions and eliminate dangerous locations the maintenance division has a gas survey crew composed of two men and a Pack-Age truck for field work. A systematic procedure of testing manholes is used, the entire city being worked by sewer district maps as the planned maintenance program requires. The Union Carbide Company's combustible Gas Indicator and also a Mason Gas Leak Indicator are used and kept in working condition by the Gas Survey Foreman. Daily and monthly record is made of all sewer districts tested, number of manholes inspected, conditions found, dangerous locations and date reported. A card index is kept of all dangerous locations, date tested, when gas company has been notified, when rechecked, when repaired. When very dangerous conditions are found the Sewer District Foreman and Superintendent and the Utility Company are notified immediately. This method of maintenance with the equipment provided has made it possible to increase the manholes tested from 1000 per year to 5,000 per month, or 60,000 manholes tested per year. This nearly covers the entire city each year.

Safety Measures and Instructions are issued to all maintenance employees, concerning entering manholes, use of safety belts, lights in or near structures, use of cannister and hose type masks, ventilating to reduce dangerous gases, use of water to clean air, instructions on first aid and simple test for detecting poisonous gases such as silver coin, strips of polished brass, or paper dipped in sugar of lead solution.

The following procedure helps eliminate explosive hazard and dangers in manholes and sewers.

1. Systematic inspection, using gas detector.
2. Elimination of illuminating gas leaks.
3. Proper disposal of inflammable liquid by inspection of gas and oil filling stations, garages and repair shops.
4. Ventilation.
5. Protection on entering sewer manholes.
6. Filling in cavities or unused structures.
7. Investigating complaints of odors and following up those that are considered of a dangerous nature.
8. Cooperation between City and Utility Companies.

Ventilation

Ventilation is important for the proper maintenance of sewers. "The Operator of the Disposal plants wants sewage delivered to him in aerobic condition, and it is no excuse to say the distance is too great. In a fast flowing sewer many miles long aerobic conditions can easily be maintained by ventilation; but if it is deliberately closed up so that fresh air is no longer available the maintenance of aerobic conditions are practically impossible. When there are complaints of smell, such conditions discloses the need of more ventilation, so let the smell out by letting the air in." *(11)

Wet side walls in a manhole are a sign of poor ventilation. In small pipe or separate systems if effective inlet is provided by vented manhole covers, sufficient outlet is provided by the house stack vent. Placing traps in house connections, sealing manholes because of odor or noise, so air cannot be sucked into the sewerage system is poor practice, but in a great many cases it is necessary.

In large outfalls forced draft seems to be necessary and at the present time two such ventilation stations have been constructed on our outfall sewer for experimental purposes. In the very near future the Design Division will have several ventilator plants ready for construction, where the "required number of air changes per time unit will be attained, which is the science of air ventilation and corresponds to the process of nature." *(12)

Conclusion

All functions concerning Sanitation are interlocked and work together. As changes are occurring in modern scientific research, people are realizing thru News items and Public Relations Programs the part that proper sanitation may play in preventing premature death and in making life more pleasant.

The Sanitary Division and Disposal of Waste is under Mr. H. P. Cortelyou, Deputy City Engineer of Sanitation and Mr. F. A. Batty, Superintendent of Sewers. Mr. Lloyd Aldrich is City Engineer.

Discussion:

By Fred D. Bowlus, Resident Engineer, Los Angeles County Sanitation Districts

In the maintenance of a sewerage system designed for disposal of domestic and industrial wastes, continuous uninterrupted flow is an all-important function. It is seldom possible to shut off a sanitary sewer for any length of time, and is costly to construct and operate a by-pass. Eternal vigilance is also required to prevent, so far as possible, the inflow of storm water, since this would reduce the

designed capacity. In a metropolitan area street work and public utility construction and maintenance must be closely followed to prevent impairment of the steady sewage flow.

Protection of a sewer structure from internal disintegration is insurance on the original investment. This attack from within is largely due to acids, either diluted with the sewage itself or formed on the walls above by sulphur-splitting bacteria. Remedial measures can only be adequately applied when knowledge of the system is acquired through tests of the sewage and sewer air.

The Los Angeles County Sanitation Districts now maintain 200 miles of trunk line sewers, varying in diameter from 8 inches to 10½ feet. Feeding into this system are over 500 miles of sewers maintained by Los Angeles County, and 750 miles of local lines serving 23 incorporated cities. After twelve years of operation, the ever-increasing sewage flow will total 30 M.G.D. before the end of 1940. Materials used in the construction of the trunk line system have included vitrified clay, concrete and reinforced concrete. Several miles of monolithic structures were so installed. These were lined with a glazed tile facing, using a special joint compound.

A crew of two or three men make occasional tests of sewage and air conditions, the data being used for sulfide control and general administrative purposes. Every mile of the County Sanitation Districts sewerage system is thoroughly cleaned at least once each year and some more often. Three-man crews seem to be the most efficient, operating from a Ford truck. Altho removal of sludge, slime and sand are most important, a considerable amount of brick spalls, wooden blocks and metals are also recovered. Lines up to 24 inches in diameter are cleaned by passing balls through the pipes. (Fig. 1). Two or three layers of burlap are sewed onto heavy rubber balls and a rope bridle attached. The ball is propelled by the sewage itself. However a rope, paid out from an apparatus at the manhole top, retards the ball sufficiently to give the desired jetting action ahead. Wear on the rope as it makes the right angle turn into the pipe from the manhole above, is prevented by a portable mounted pulley. (Fig. 2). A light hardwood snubbing winch fitted over the manhole rim provides simple control of the rope tension. (Fig. 3). As the ball nears each manhole, it is temporarily stopped with a wooden disk and a prop, while the debris is shoveled into a bucket and hoisted.

In pipes with diameters between 27 and 48 inches, a wooden disk slightly smaller than the pipe is used. (Fig. 4). The disk is held upright by a 4" x 4" wooden tongue extending aft, strap irons being bolted to its end to maintain the timber horizontally. Segments of tire casings nailed to the disk rim streamline the apparatus. These disks also do a more thorough job of cleaning when restrained by a back stay rope. In the larger structures a hoe type wooden drag (Fig. 5) with a tongue floating astern, built only high enough for the particular sewage flows encountered, has been used with success. Several hundred pounds of concrete blocks are often attached to the blade to prevent its skipping over sand and other debris. These hoes have removed hundreds of tons of sand from the outfall sewers. A portable gasoline engine hoist and (Fig. 6) self-dumping bucket are used in all cases where any considerable amount of debris is to be removed from manholes. In general, time has been saved and a more thorough job done by removal of material at each manhole rather than attempting to push it ahead for any distance. Jointed flexible steel rods are available in the rare case of a ball getting stuck. These are readily punctured and dragged out with a cork screw attachment. Root growths in sewer pipes occur at very few points in the district trunks. Frequent cleaning with a ball prevents growth to any extent. Special tools are sometimes passed through lines where oil field wastes leave hard deposits. Occasionally an initial head of water has to be purchased at the upper ends of trunks to propel a ball.

Although ropes and leather belts are always available in sewer maintenance work of the County Sanitation Districts, they are seldom needed because of the thorough knowledge of sewer air conditions throughout the system. The field cost of cleaning 55 miles of sewer in 1940 amounted to $30 per mile.

The maintenance crew is also called upon to inspect all local sewers and house connections to the trunk system, and make occasional measurements of the sewage. The Districts have developed the Venturi-flume for the latter purpose.

Some installations of concrete are made, but three-piece portable sheet and cast iron flumes are used extensively (Fig. 7). Ingenious ball-bearing devices for accurately transferring float levels to stage recorders (Fig. 8), and cams to convert the logarithmic water level-flow ratio so that it will fit the regular commercial cross-sectional record paper on these machines, have been devised.

The crews also make minor repairs to sewers, adjust manhole rings and covers to fit new pavements, and make major repairs at the Districts' twelve sewage pumping plants and eight chlorine stations.

The interval between cleaning operations of a sewer depends on several factors: sewer grades, velocities, quantity of sewage, pipe materials, lateral flushing, and storm water flushing. During the past year, tests for dissolved sulfide in the sewage have been taken on three typical trunk sewers to determine the effects of sewer cleaning and natural storm water flushing. These data have been plotted as Fig. 9. Each point on the graph represents an average of continued testing for several hours throughout a period of the day when the sulfides were highest. However, the points for the combined sewage in the Joint Outfall for Districts Nos. 1 and 2 are averages of continuous 48-hour runs. Insufficient data were taken to show the true effect of the unprecedented storm of September, 1939, but by comparison with later storms of the past winter it has been assumed that a flushing effect materially reduced the sulfides for a period. That the sulfides again returned is shown by tests on both the South Bay Cities and Gardena trunk sewers. Thorough cleaning of the South Bay Cities trunk in November, 1939, caused an immediate reduction in sulfides and they have remained relatively low for nearly five months, the situation having been aided somewhat by at least two later storms. In the case of the Gardena trunk sewer, sulfide production was stopped by a combination of storm and sewer cleaning in January, but the beneficial effect lasted only about six weeks. However, the sulfides found in March were probably not as high as would have been the case without the sewer cleaning or storm flushing. Sewer cleaning on the Wadsworth trunk has been effective in reducing the sulfides for apparently only a matter of a few days.

In the South Bay Cities trunk, sulfides were being generated last fall within the trunk line itself before it was cleaned, due to deposits of sludge, slime and sand, as no tributary of any importance entered the line carrying sulfides. Here cleaning had a lasting effect. In the case of both the Gardena and Wadsworth Avenue trunk sewers, further tests have revealed that a number of contributing laterals carry sulfides. A large portion of the Wadsworth Avenue trunk sewage enters the trunk with the sulfides one and one-half miles above the point where records were obtained for the curve. Industrial wastes with sulfides entering at another point also raised them. Sewage flow during the time of sampling in these trunks averaged:

South Bay Cities	2.0 M.G.D.
Gardena	0.4 "
Wadsworth Avenue . . .	0.6 "

Tests on these lines will be continued throughout the summer, but sufficient evidence is now available to show that sewer cleaning materially reduces the sulfides.

If those laterals carrying sulfides were periodically cleaned, or possibly flushed, control would be aided.

Thorough cleaning of the County Sanitation Districts trunk sewers has necessitated men entering every manhole in the system and occasionally traversing the sewer itself between manholes. A knowledge of both the sewage and sewer gas has been paramount to the employees' safety. As a result, only minor accidents have occurred during the ten years this work has been under way. Eternal vigilance is necessary and the problem of safety has been more difficult because of intermittent strong industrial wastes. Tests of the sewer air have been made occasionally to trace the extent and concentration of hydrogen sulfide gas, depletion of oxygen and explosibility. Both commercial gas and gasoline have detectable odors, and in this case no one is allowed to enter a structure without further ventilation. Release of hydrogen sulfide gas from the sewage depends on several factors; i.e., p.p.m., velocity and pH. Twenty p.p.m. of this gas have been observed in the sewer air where a vertical drop exists in the invert, even when the sewage had less than 0.5 p.p.m. of dissolved sulfides; and in other sewers where the velocities were low and no turbulence occurred, only traces of the gas

were found in the air even when the sewage carried two to three p.p.m. of dissolved sulfides. Turbulence is a major factor in H_2S release.

At one manhole, sewage from a lateral with 3 to 5 p.p.m. of dissolved sulfides dropped into a trunk with none. H_2S in the air was 60 p.p.m. at the manhole, but only one-third that amount in a structure less than 100 feet away. This reduction was due in part to immediate conversion of the gas into sulfuric acid by bacteria on the sewer walls and in part to re-absorption into the larger flow of sewage in the trunk line.

The maintenance crews often work many hours each day in sewers with H_2S concentrations of 10 to 20 p.p.m. Most authorities agree that 200 p.p.m. are tolerable, with signs of distress not noticeable until 500 p.p.m. are found. Of late tests show a peak of 100 p.p.m. in the County Sanitation Districts System. A few tests of the Los Angeles City North outfall sewer show this is not exceeded in that sewer. Tests of sewer air have also revealed that high H_2S usually is accompanied by oxygen depletion. Where 50 to 100 p.p.m. of the gas are found in the sewer air, oxygen deficiencies of five percent have been measured. However, lack of oxygen may occur even when H_2S is low. One recent test of a structure where a man had been overcome some years ago, showed only 12% of oxygen when less than 1 p.p.m. of H_2S was measured in the air.

Because the sewage of Southern California has a higher temperature (20° to 26° C.) than in more northern climates, operation and maintenance of a large sewerage system here usually requires control of sulfides in addition to the ordinary work. Efficiency depends upon the diligence with which the problem is attacked. Two men of ordinary intelligence may readily be taught the methods of sewage testing, and even though only part of their time is devoted to this work, will obtain a surprisingly comprehensive picture of a system in a few months. The apparatus is not expensive. The County Sanitation Districts have demonstrated that thorough cleaning of their trunk sewers has materially aided sulfide control. As a result of further research and recent adjustments in the chlorination program, sewage enters the head of the Joint Outfall sewer from the several districts with practically no dissolved sulfides at any time. Complete protection of this large outfall structure for its entire length, and odor control at the Joint Disposal Plant, will be effected in the near future. Studies on the treatment of sewer air by ventilation and by application of ammonia gas are nearly complete.

LABORATORY TESTS FOR THE SEWAGE PLANT OPERATOR

By **RICHARD POMEROY**
Chemist and Bacteriologist, Harbor City, California

Many articles have been written and many talks have been given about the value of tests in the operation of sewage treatment plants, and about the importance of the keeping of chemical records as part of the duties of the operator. Some operators have taken this very seriously, have secured imhoff cones, pH sets, thermometers, sulfide sets, and equipment for running dissolved oxygen, B.O.D., nitrites, suspended solids, etc. They have begun to make tests, and to fill page after page with records. And then one day when the digester is foaming, a motor goes flooey, the screw-feed sludge pump plugs up, and there is a shot of oil to skim off the primary all at the same time, the operator is so busy that he forgets about the tests for two or three days. When he gets caught up he begins to wonder if his failure to take all of the tests every day has made much difference after all. Perhaps he has the bolshevik thought that he has spent a lot of time to collect a lot of records

to collect a lot of dust, and that he might just as well junk the whole business.

The decision of such an operator to quit most of this testing is probably correct, for if all of the useless chemical data recorded at sewage treatment plants were laid end to end they would only collect more dust. There are plants which make daily records of the pH at the influent and effluent end of plain sedimentation tanks—tests which rarely are of any value. There are plants which make weekly determinations of the B.T.U. value of the gas. There are plants which fill books with relative stability tests on raw sewage which always turn white within a few hours except after storms, and there are other plants which have books filled with stability tests on effluents which never turn white in twenty days. There are records of pH tests on digesters, always showing values from 7.6 to 8.0 and higher, although the true pH of digesting sludge can never be higher than 7.6. There are plants which make daily determinations of the volatile content of the suspended solids of the sewage, and daily determinations of the pH of raw sludge—tests which are generally useless even in the largest plants.

It may seem surprising that a chemist should speak so disparagingly of chemical tests. However, the criticism is not of chemical tests, but of the useless repetition of tests which have long ago ceased to provide valuable information. What is needed is a better understanding of the wide variety of available tests in this field, and of the significance of the results. For every plant which has been wasting time on useless tests, there are two which have neglected to secure needed data. The need is not for fewer tests, but for more intelligent tests.

The operator must not judge the value of tests solely by the aid they may give him in the operation of his plant. Tests may be of value to the engineers, to city officials, and to the sewage disposal industry at large. The operator should have knowledge of the efficiency of each unity of his plant. By comparing the efficiency of similar units in various plants, conclusions can be reached as to the relative merits of different designs. Records of the performance of a plant indicate the time when additional capacity will become necessary. In fact, the main foundation of all expansion and progress in sewage treatment is laid with the performance records of existing plants.

If you have a primary sedimentation or Imhoff tank unit, what tests should be made? Every operator having one of these units should have Imhoff cones and should know the removals he is getting. If it is practical, and especially in the larger plants, he should have suspended solids determinations also. This does not mean that tests must be made day after day and year after year. Nor does it mean that the operator should consider the removal to be what he would by two or three tests made ten years ago. In the average plant, tests made once a week or once a month are sufficient, provided the samples have been taken with due attention to the difficulties of securing representative samples of raw sewage.

Knowledge of the concentration of sludge drawn from plain sedimentation tanks is valuable, but the securing of a true average sample of all pumpings from such tanks is extremely difficult, and in most cases all but impossible. Most published data on primary sludge concentrations are doubtful for this reason. They may give some indication of the solids content while thick sludge is passing, but they seldom include a proportional amount of water or

very thin sludge which constitutes part of the pumpings in most installations. If the sludge from the sedimentation tank is first removed to a collecting tank, it is then much easier to determine the concentration, and also the volume removed.

Determinations of grease removal in primary units are sometimes desired, but grease analyses are difficult and should not be undertaken by anyone who has not had considerable experience in laboratory work.

In some cases sulfide generation is serious in primary tanks, especially where the detention time is long. If this condition is suspected, then of course sulfide tests should be made. Such tests may point to the desirability of reducing the detention time by running fewer units where this is possible, or by returning effluent to the raw sewage if the primary is followed by an oxidation process, or other sulfide control measures may be indicated. In this situation, as in all cases involving sulfide tests, the operator must realize that sulfide concentrations are extremely variable. Hence many tests must be made at various times of the day and at different seasons if one is to know the true conditions.

While the chief value of the data on efficiency of sedimentation tanks is for others, it may be useful to the operator in some instances, particularly if he wishes to compare different operating schemes, such as the effect of running two tanks in contrast to putting all of the sewage through one tank, or variations in the sludge pumping schedule. Here the operator must be warned against too little testing, for in such situations conclusions as to the relative merits of different schemes are not reliable unless based upon at least 25 tests.

If the operator has a digester, what tests are of value in its performance? The best indicator of day-to-day efficiency is gas production. The gas-meter reading should be made and recorded each day. The output of gas in cubic feet per cubic foot of tank volume provides an interesting basis for comparing the capacities of tanks. Gas production per pound of volatile solids added is often used to rate the performance of digesters, but only rarely can the input of volatile solids be determined with sufficient accuracy to yield results of significance.

The determination of volatile acids in sludge liquor is a good measure of completeness of digestion. This test is valuable in regulation of digestion systems which practise controlled seeding, and in other stream-lined high-speed digestion systems, but it is not of value in small one-stage digesters.

Volatile or organic content of the sludge is sometimes used to determine the completeness of digestion. This is all right in large installations, but is out of place in small plants.

A well-known test in the field of sludge digestion is the pH. When the tank is behaving badly, the pH should be tested, and if a value below 7.0 is found the tank is too sour. Various corrective measures may be indicated which will depend upon other circumstances and which cannot be discussed fully in this brief paper. When the pH is above 7.0 its determination tells nothing of value, and need not be made routinely. If your digester shows a good output of gas and is not sour, and if the sludge dries without nuisance, you don't need any chemical tests to tell you that operation is satisfactory and that sludge from the bottom is adequately digested.

Determination of the volatile content of dried sludge gives some indication of its fertilizer value, for the nitrogen content is generally 5%-6% of the volatile content. Direct nitrogen determinations are better and should be made occasionally in the larger plants whose sludge is used for fertilizer.

Oxidation plants provide reasons for many tests. In the case of activated sludge the measure of sludge concentration by settling in cylinders is best known. No general rule can be laid down for the frequency of this test. Plants which operate under stable conditions, with ample capacity and no great variation of sewage strength may run for long periods with no change in the settings of pumps and valves which control the return and wasting of the sludge. In such plants sludge concentration tests will be quite occasional after efficient operating conditions have been determined. But in plants which have no reserve capacity or which suffer from the irregular discharge of industrial wastes such tests may be necessary daily or even three times a day.

Occasional determinations of suspended solids in aeration tanks are valuable, but only in the largest plants is it practical to make these for control purposes.

Measurement of dissolved oxygen in the effluent is highly important in activated sludge plants, and is of some value in trickling filters. In the final clarifiers of activated sludge plants an oxygen content of 1-2 p.p.m. is sufficient. If the oxygen content rises above 4 p.p.m. the operator may cut down the air supply and thus conserve power. If the dissolved oxygen becomes too low, obviously the air supply should be increased. If this cannot be done, the deficiency may be remedied by cutting down the circulating load. It is better to have a low concentration of properly aerated sludge than to have a lot of semi-septic sludge.

Determinations of relative stability are customary in the smaller oxidation plants. These show in a rough way the adequacy of treatment. A much better measure of efficiency is the B.O.D. test. The B.O.D. removal in oxidation units should be determined wherever possible. This does not mean testing every day except in large plants. Suspended solids determinations on the effluent are likewise valuable. Turbidity tests are easily made when suitable equipment is available, and give results nearly as significant as suspended solids determinations. When variations of operation are being tested, as many as possible of these tests of efficiency should be applied.

Nitrites and nitrates have been much used in the past as indicators of the completeness of treatment by oxidation processes. It is now recognized that these compounds are of no great value in themselves and that plants can often be run more economically if the detention and air supply are below the level necessary for maximum nitrification.

When chlorination is used for sterilization of effluent, enough chlorine residual tests should be made to establish proper dosages. Sometimes chlorination ahead of a plant is used for odor control. In this case the dosage should be just enough to remove sulfides as shown by the sulfide test. Sulfide control measures in sewers necessarily require tests for total sulfides, dissolved sulfides, and hydrogen sulfide. These tests are essential in the determining of remedial measures to be used, and in the regulation of such control measures. No general statements can be made as to methods of control, for there are at least ten methods which have various fields of usefulness. Adequate study by a

chemist who is an expert in this field—and who has nothing to sell—is essential for the economic solution of sulfide problems.

Likewise in industrial waste situations the possible tests are too varied to list here, and it is impossible to present enough chemical background to guide one in the solution of such problems.

What was said in the introduction to this paper about useless records is not to be construed as encouragement to laxity in the recording of such tests as are made. Every test which is worth making is worth recording. No one can condone the operator who thinks it is enough to carry results in his head. Records of varied tests are more difficult to keep than routine records, but vastly more important. If tests are wisely selected, the records will not be dust collectors; they will be used to answer vital questions.

If necessary, find out from a qualified chemist what tests to make in your situation, how to make them, and what is the significance of the results. If you approach the question in this way, you will have no doubt of the value of tests to the sewage disposal industry.

ELECTRICAL EQUIPMENT IN SEWAGE PUMPING AND SEWAGE TREATMENT PLANTS

By **FRANK A SHORT**

Engineer, Industrial Accident Commission, State of California

Electrical Rules and Regulations

The National Electrical Code contains special requirements relating to electrical wiring and equipment in hazardous locations.

The Code defines and describes certain processes and certain portions of the buildings where such processes are carried on as hazardous locations. The substances which cause these hazards are divided into the following general classes:

1. Class I—Flammable liquids, gases and vapors.
2. Class II—Combustible dusts.
3. Classes III and IV—Easily ignitible fibers.

When the present Electrical Safety Orders (which became effective May 1, 1934) were being prepared, the Committee felt that the National Electrical Code requirements covering Class I hazardous locations were too strict to apply in places where flammable gases or liquids are handled in closed pipe and container systems. The Committee, therefore, divided hazarous locations Class I into Class I-A and Class I-B locations. Class I-A locations are described as those enclosures in which flammable volatile liquids, highly flammable gases, mixtures, or other highly flammable substances, are manufactured, used, or handled in open containers, or are stored in such a way that a hazardous condition may continually or frequently exist in the atmosphere.

Class I-B locations are described as those enclosures in which flammable

volatile liquids, highly flammable gases, mixtures, or other highly flammable substances, are manufactured, used, handled, or stored in closed containers or closed systems in such manner as to normally prevent escape and accumulation of such flammable substances with resultant creation of hazardous atmosphere.

The Electrical Safety Orders of the Industrial Accident Commission of the State of California set up a minimum standard of safety in all places of employment in this state, therefore those orders apply to sewage pumping plants and sewage treatment plants. Where city or county Electrical Inspectors are making inspections under their local ordinances in places of employment coming under the jurisdiction of the Industrial Accident Commission, the Electrical Safety Orders must be considered as setting the minimum standard for those installations.

While sewage pumping plants and treatment plants are not specifically mentioned in the Electrical Safety Orders as hazardous locations, the Industrial Accident Commission feels that they should be so treated.

Explosions in Sewers and Sewage Plants

There have been a number of explosions in such plants. In addition to those explosions which have occurred in California, several have been reported from other states. A few of those of which we have a record are as follows:

(1) An explosion occurred in the dry well in a sewage pumping plant of a California City. An employee of the City stated that he removed the manhole cover and went down into the dry well and started the motor, to see if the pump was working properly. He then stopped the motor, when an explosion occurred which burned him severely. There was a ventilating fan which was supposed to have been started from a switch on a pole across the street before anyone entered the dry well. This man did not start the ventilating fan. Explosive vapors had collected in the dry well and were undoubtedly ignited by the arc caused by the opening of the contactor when the motor was stopped. The paper on the inside of one of the contactor cases was scorched.

(2) An explosion occurred in the dry well of a sewage pumping plant in another California City. Three men were burned in this explosion. One of the men was so severely burned that he was found to have permanent disability. The explosion was very severe, completely destroying the wooden building above the dry well. The man who was most severely injured stated that the other two men were in the building above the dry well, and that he had climbed the ladder to the top of the dry well when his shoulder struck a lamp on the wall beside the ladder, breaking the lamp and causing the explosion. There was testimony that the three men had been cleaning the pump with kerosene, preparatory to painting it. All of the testimony was to the effect that no gasoline was used, and that the bucket of kerosene was removed from the dry well after the explosion and had not been burned.

(3) An explosion occurred in the pump house of one of the sewer pumping plants of another California city. This explosion was reported by the Fire Department as follows:

> Fire Alarm: Verbal.
> Cause of Alarm: Men welding with torch nearby.
> Nature of Fire: Sewer gas explosion. No loss.

Gas had collected in concrete underground chamber under plant used as a sewer booster plant.

Occupant: Sewer Department. Employees were working there at the time.

Response to Fire: Engine Company No. 6 and Battalion Chief. Worked 23 minutes. Hose used: 350'.

(4) An explosion occurred in a sewage pumping plant of another California city. A report of this explosion was submitted by the City Electrician, as follows:

"The explosion of sewer gas happened at the sewage disposal plant. The attendant opened a switch and the electric arc ignited the gas which was trapped in the switchboard enclosure. All of the insulation on the wire in the switchboard took fire and burned. It was necessary to rewire the switchboard. The switchboard was located approximately four feet from the screen and on the wall above the wet wall. In my opinion the gas entered from the bottom of the box. Since then we filled the bottom with concrete and have had no further trouble."

(5) Other explosions have occurred in sewage pumping plants in this state, but no definite information has been obtained concerning these.

(6) The following fires and explosions outside of California are some of those reported by the National Fire Protection Association:

a—April 25, 1915, Ocean Grove, N. J. This explosion and fire occurred during the inspection of the sewage disposal plant by a group of municipal officials from another town, and cost the life of one of the visitors and severely burned another. The inspection party had been making a tour of several sewage disposal plants, and on arrival at Ocean Grove proceeded to inspect the plant without first getting in touch with the Superintendent of Sewers. A manhole cover was removed from the sludge digestion tank and two of the party had entered the tank and a third was entering when the first man to enter struck a match, probably to find his way about. There was a flash followed by an explosion. The man just entering was blown through the manhole and burned. The second man to enter the tank succeeded in reaching the rim of the manhole, where he remained until dragged out. He was so severely burned that he died that night. The first man to enter the tank, whose act was responsible for the explosion, was thrown into the corner of the tank under the manhole and was severely burned. He was later carried out. The tank itself was apparently undamaged. There must have been a considerable quantity of gas present for the tank had not been ventilated prior to the inspection.

b—July 23, 1917, New York City. An explosion occurred in a sewer resulting in injury to a number of people. The garage of an exprss company was suspected of being one of the chief sources of the waste gasoline thought to have been the cause of this explosion.

c—January 27, 1920, New York City. An explosion occurred in a sewer at Times Square. Car windows were broken but no one was injured.

d—February 17, 1921, New York City. An explosion in a sewer killed a workman.

e—June 7, 1926, New York City. A sewer explosion occurred near Broadway and 125th Street, causing injury to several persons. Considerable quantities of oil in the sewer were set afire by this explosion.

f—June 8, 7926, Baltimore, Maryland. An extensive fire in a sewer was caused by a match thrown into an open section of a storm drain. A considerable quantity of oil and kerosene was found in the open ditch and in the covered sewer sections.

g—September 16, 1929, Newburgh, N. Y. One person was killed and 25 were injured and damage estimated at $200,000.00 was done to property in a series of explosions which took place in a sewer. The explo-

sions were believed to be due to the ignition of vapors from benzine, gasoline or illuminating gas.

h—October 24, 1929, Boston Mass. An explosion occurred in a sewer trench on River Street when a workman stuck a pick into a power cable and caused an arc which ignited the sewer gas.

i—October, 1930, Mt. Ephraim, N. J. An explosion occurred in a sewer plant. It was believer that a manhole cover of the sludge digestion tank was removed and a match thrown in.

j—October 2, 1931, Woonsocket, R. I. An explosion occurred in the concrete sludge digestion tank. Two men were killed. A large loss occurred.

k—October 2, 1934, Middleton, N. Y. A fire in a bar screen chamber caused by gasoline waste which had entered the plant with sewage, caused a moderate loss.

l—Ottawa, Canada (date not given). Terrific explosions, believed to have been caused by waste gasoline leaking into the city main sewer, rocked the downtown section of Ottawa, causing the death of several persons and injury to many others. Heavy manhole covers were tossed high into the air, followed by loud reports and bursts of flame.

Reports covering a number of other explosions and fires in sewers and sewer plants could be cited, but those given above give convincing evidence that a fire and explosion hazard in such locations does exist.

The following is quoted from the National Fire Protective Association Quarterly, Vol. 26, 1932:

> "Although the existence of an explosion hazard in sewage disposal plants had been known for some time, it was not until after the Woonsocket, R. I., disaster on October 2, 1931, that any serious consideration was given to the subject. The explosion at the Woonsocket plant, costing the lives of ten workmen and causing considerable property damage, served to emphasize the fact that modern methods of sewage treatment and disposal are becoming continuously more hazardous and to indicate the need for proper and adequate safeguards."

The following is quoted from the April, 1930, Quarterly of the National Fire Protective Association:

> "Gasoline and oil from filling stations, garages and automobile repair shops, and other volatile flammable liquids used in various manufacturing processes, are often discharged into sewers, and the gases from them are likely to create conditions making for the possibilities of flash fires and explosions. Ordinances and regulations prohibiting the discharge of flammable liquids into sewers have been adopted by many cities, and the number of communities having such legislation is constantly increasing.
>
> "In 1928 an interesting report was made of the results of a survey made by the Sewer Department of the District of Columbia relative to the disposition of waste crankcase oils. This survey was occasioned by the realization of the hazards brought about by large quantities of crankcase drainings entering the public sewers. It was ascertained that these drainings usually contain gasoline in an amount sufficient to vaporize in the sewer, thereby creating a combustible gas capable of ready ignition, resulting in explosions or fire. It was also determined that the gas thus created, being heavier than the warm air inside the sewers, does not readily escape from air vents."

Inflammable liquids which are run into sewers by various industries may introduce a hazardous condition at any time and, if at that particular moment there is an electric arc or flash, the gases from these liquids may be ignited. These gases are in addition to the sewer gases commonly found as the result of decomposition of organic matter. The presence and volume of gases of this type would naturally be expected to be greater in certain localities than

in others. A survey was made about three or four years ago to determine the amount of flammable solvents being run into the sewers of one California county by the cleaning and dyeing industry. It was found that approximately 860 gallons of free naphtha was being run into the sewers per day from that industry alone, in addition to a considerable amount of solvents run into the sewer system by the automotive and other industries.

Special Types of Electrical Equipment Required

In determining the type of electrical equipment to be installed in sewage plants, the wet well should be treated as a Class I-A location, since there may be explosive gases present at any time; while the dry well and all portions of the building into which the dry well opens should be treated as a Class I-B location, since gases would not normally be present in that location, but might escape from the pumps or valves due to leakage.

Squirrel-cage motors (which have no arcing or sparking parts) may be used in Class I-B locations.

The main switchboard must be installed outside of the pumping plant or in a separate room with an entrance from the outside of the building. This room should have no connection with the room above the wet well or dry well.

The float switches may be of the mercury switch type enclosed in explosion-proof fittings.

The following excerpts from the Electrical Safety Orders should be given special consideration when laying out sewage pumping plants and treatment plants:

> For Class 1-A locations, fuses or cutouts shall be mounted within approved explosion-proof enclosures. The fuses, cutout bases, and their enclosures shall be approved as unit devices for use in explosive atmospheres. Circuit-breakers shall be of a type approved for use in explosive atmospheres. For Class 1-B locations, fuses, cutouts, and circuit-breakers shall be of the type permitted for Class 1-A locations or of a type having all arcing or sparking parts immersed in oil, or may be enclosed in a vapor-proof enclosure. Fuses, cutouts, and circuit-breakers shall not be installed in either Class 1-A or Class 1-B locations if it is practicable to install them in non-hazardous locations.
>
> For Class 1-A locations, motor controllers, thermal cutouts, switches, relays, the switches and contactors of auto-transformer starters, resistance or impedence devices, or other devices or apparatus, which in their normal operation tend to create arcs, sparks, or high temperatures, shall be of a type appoved for use in explosive atmospheres. For Class 1-B locations, such devices or apparatus may be installed in vapor-tight enclosures, or may be of a type having all sparking contacts or high temperature parts immersed in oil. Such sparking or arcing equipment or devices shall not be installed in either Class 1-A or Class 1-B locations if it is practicable to install them in a non-hazardous location.
>
> For Class 1-A locations, switches controlling lighting circuits shall be of a type approved for use in explosive atmospheres. For Class 1-B locations, switches controlling lighting circuits shall be of a type having all sparking or arcing contacts enclosed in a vapor-tight enclosure or shall have such contacts immersed in oil. For both Class 1-A and Class 1-B it is preferable to install such switches in non-hazardous locations. For both Class 1-A and Class 1-B locations lamps in fixed positions shall be installed in fixtures of the enclosed vapor-tight type and shall be properly protected by substantial metal guards or other approved means where exposed to breakage. For both Classes 1-A and 1-B sufficient general illu-

mination shall be provided by fixed lighting units to eliminate, so far as possible, the need for portable lamps. When portable lamps are necessary in either location, they shall be of the enclosed vapor-tight type. Portable lamps shall be properly protected by substantial metal or other approved type of guards to prevent breakage. Sockets for portable lamps shall be of the keyless type with no exposed metal parts. When it is necessary to use portable lamps, or other portable current consuming devices in either Class 1-A or Class 1-B locations, approved flexible cord designed for hard usage such as Type S or Type PA shall be used. For Class 1-A locations, such flexible cord shall contain one extra insulated conductor whuch shall be properly connected to form a grounding connection for metal lamp guards, motor frames, and all other exposed metal portions of such portable lamps and devices. For Class 1-B locations such flexible cord shall contain an extra insulated conductor which shall be properly connected to form a ground connection for motor frames and all other exposed metal parts of devices other than portable lamps.

For Class 1-A locations, receptacles and attachment plugs shall be so connected as a part of a unit device with an explosion-proof interlocking switch that the plug cannot be removed while the switch is in the "on" position, or approved devices which seal the arc made when the current is interrupted by means of an explosion-proof enclosure, shall be used. Such receptacles and plugs shall be of the polarized type providing a connection for the grounding wire of the portable cord. For both Class 1-A and Class 1-B locations, receptacles and attachment plugs shall not be installed if it is practicable to install them in a non-hazardous location.

THE SEWAGE SITUATION OF LOS ANGELES

By **FRANKLIN THOMAS**

Professor of Civil Engineering,
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Historical

Scarcity of water was probably a major factor in the circumstances which caused the City of Los Angeles to adopt a crude form of sewage disposal by using the flow for irrigation instead of emptying it into the bed of the river. An extended period of drouth was about to be ended by the wettest winter of record, 1883-84, bringing 38 inches of rain; when in 1883, the authorities of the city of about 15,000 people made a contract with the South Side Irrigation Company for the sale of the sewage of the San Pedro Street sewer. The flow amounted to 3.58 cu. ft. sec. and with later increases, a supplementary contract of 1895 (when the population had reached 70,000) agreed to deliver 6 cu. ft. sec. or more until 1903. The prevailing price was at the rate of $2 per acre foot. The company irrigated about 2200 acres.

Objections of the health authorities to the use of sewage for irrigation of vegetable farms, and the growth of the City in the direction of this land, resulted in the abandonment of the practice with the completion of the Central Outfall to the West in 1907, at which time the City had a population somewhat over 200,000.

Los Angeles' first outfall extended 10 miles to Hyperion and was constructed of brick with diameters of 4.5 feet to 6 feet and had a capacity of 90 cu. ft. sec. At the ocean the line connected with a 52 inch redwood pipe

carried out 2000 feet upon the Hyperion pier to a submerged end. After about 20 years of service, the Central Outfall had been subject to so much disintegration that its use was discontinued except for the minor flows from El Segundo and the Municipal Airport.

The exceptional post-war development which took place in Los Angeles had taxed even by 1920 the capacity of the Central Outfall Sewer, while the nuisance and menace created by the discharge of that volume of unscreend sewage near the shore had aroused justifiable complaints and official threats. Early in 1921, a "Special Sewage Disposal Commission," composed of George W. Fuller, George C. Whipple, and William Mulholland, investigated the situation and submitted a report the findings and conclusions of which as confirmed by subsequent events and developments, still constitute a sound general pattern to be followed in a comprehensive program of sewage disposal for Los Angeles. Facilities which have been provided fall far short of those recommended by this Commission, but nothing which has been done is in serious conflict with their recommendations.

The Commission, in April, 1921, recommended in part: That a new ocean outfall be constructed of a capacity at least 325 cu. ft. sec.; that a plant for fine screening of sewage be installed; that the screened sewage be dispersed at Hyperion by means of deep multiple outlets; that an activated sludge plant of at least 2,500,000 gals. daily be built to explore the suitability of the process for this system with provisions for adding other units when desired. It was anticipated that one of two suggested locations would be used: (a) near the Baldwin Hills with the effluent being used for irrigation or being discharged into Ballona Creek; or, (b) near the Los Angeles River in the southeastern industrial district.

At a sewer bond election in June, 1921, when a proposition for $12,250,000 was submitted, the voters expressed overwhelming disapproval. The defeat was due principally to objection by civic bodies and newspapers to discharging increasing quantities of raw sewage adjacent to populous beach areas and to the contentions of conservation advocates that the constituents of the sewage should be put to economic use.

In August, 1921, subsequent to and in view of the defeat of the bond proposal, the Special Sewage Disposal Commission submitted a supplementary report involving a reduced project estimated to cost $4,000,000 and which omitted the controversial new outfall sewer to Hyperion. However, before official action was taken concerning another election, the very heavy and continued rains of December, 1921, caused such overloading of the sewers in the southerly part of the city that manhole covers were floated and sewage ran in the streets. A break occurred in the Central Outfall operating under pressure and escaping sewage flowed into Ballona Creek.

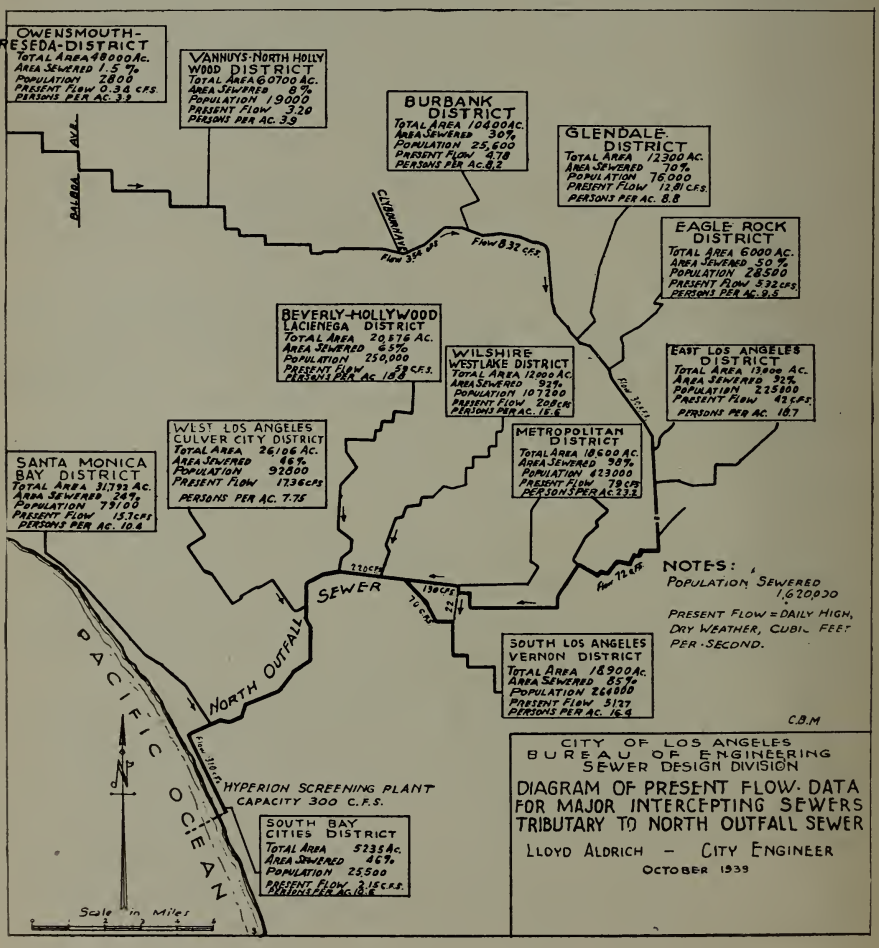
These alarming conditions awakened public responsibility and aroused civic leadership to a point where temporary makeshifts were abandoned. By common consent a project was formulated providing: for a screening plant on the Central Outfall; for the much maligned North Outfall with intercepting branches to relieve overloaded trunk sewers; for a screening plant on the new outfall and for a submarine discharge line extending 5000 feet into the ocean. In August, 1922, a bond proposition for $12,000,000 was approved by a four to one vote. The new facilities were rushed to completion and went into service in 1924 and early 1925. For approximately nine years

of the Los Angeles River as the line turns toward the West Coast 22 miles away, the elevation is 225.

the screenings were ejected to the top of the sand dunes adjacent to the beach at Hyperion, but in 1934, an incinerator for these screenings was placed in operation and the dewatered solids were burned. In 1937, operation of the incinerator ceased when an arrangement was made for the screenings to be hauled away without cost to the City. Shortly after the completion of the North Outfall, use of the old Central Outfall was largely abandoned due to its physical deterioration. Except for a detached treatment plant at Los Angeles Harbor and some new relief sewers, the City's system has been little modified since 1925.

Geographical and Topographical Features

While the pattern of trunk sewer locations in most cities resembles a fan, in Los Angeles it resembles a letter "U" because of the Santa Monica Mountain Range which separates San Fernando Valley from the Coastal Plain.



NORTH OUTFALL SEWER

Distribution of Area, Population; Capacity and Dry Weather Daily High Flow, 1939

Distance from Hyperion Miles	Hours	Tributary District Junctions	Area District	Area Percent Sewered	Persons per Acre	Population District	Population Accumulated	Flow c.f.s.* District	Flow c.f.s.* Accumulated	Capacity c.f.s.
53.5	18½	Canoga Park	48,000	1.5	0.06	2,800		0.34		
42	13½	Van Nuys—North Hollywood	60,700	8	0.31	19,000	21,800	3.20	3.54	51
33.5	10	Burbank	10,400	30	2.5	25,600	47,400	8.2	11.74	60
30	8½	Glendale	12,300	70	6.17	76,000	123,400	12.81	24.55	
27	7½	Eagle Rock	6,000	50	6.75	28,500	151,900	5.32	29.87	72
25	7	East Los Angeles	13,000	92	17.3	225,000	376,900	42	71.87	121
19	5	Metropolitan	18,600	98	23.2	423,000	799,900	79	150.87	185
11	3½	South Los Angeles—Vernon	18,900	85	14.0	264,000	1,063,900	51.27	202.14	
10.5	3½	Wilshire—West Lake	12,000	92	8.94	107,200	1,171,100	20.8	222.94	340
9.75	3	Beverly—Hollywood	20,576	65	13.02	268,000	1,439,100	53	275.94	
8.75	2	West Los Angeles	26,106	46	3.54	92,800	1,541,900	17.36	293.30	450
3	1	Santa Monica Bay	31,792	24	2.49	79,100	1,621,000	15.7	309.00	
....		Hyperion					1,621,000		309.00	450

*Due to the fact that the daily high flows from different districts do not coincide in the outfall, the actual dry weather peak at Hyperion is 275 cfs.

The distance by airline from the head of the North Outfall in the Canoga Park region to Hyperion is 21 miles, but the distance along the natural drainage of the Valley around the east end of the Santa Monica Moutains, thence to the west coast is 55 miles. This line then is affected by the complications and difficulties which might be expected to beset the longest closed sewer in the world.

The elevation of the upper end of the North Outfall 55 miles from Hyperion is 800, while 23.5 miles downstream where the line makes the bend around Griffith Park the elevation is 600. At the Enterprise Street Crossing

The table on page 6 shows that the sewage from the most remote areas of the Los Angeles system, although small in amount, requires over 18 hours to reach Hyperion. The flow approximating 20 c.f.s. as a daily peak, from the Glendale junction has an 8½ hour journey to the ocean, while 150 c.f.s., or half of the flow at Hyperion, travels from the junction of the tributary serving the business district for 5 hours in the North Outfall. Expressed in the reverse order, 95% of the flow is 3 hours or more old; 75% is more than 3½ hours old; 50% is 5 hours old; and 20% has been in the North Outfall 7 hours when it reaches Hyperion.

Metropolitan Aspects

The authorities of the City of Los Angeles at various times in the past have exemplified the "Good Neighbor Policy" toward a number of the adjacent smaller communities, in respect to assuming the responsibilities of sewage disposal. In a number of instances the generosity represented by the terms of the agreements with these communities is of a scope showing little regard for the interests of Los Angeles. Examples of some of the arrangements are: One city of 70,000 persons acquired a perpetual right to discharge through 25 miles or more of outfall sewer, all of its sewage with no limitations on quantity in return for the construction of a few miles of the outfall which also serves as the carrier for sewage from some of the more remote portions of Los Angeles. Some cities make annual payments for operation and maintenance expenses on a basis of measured flow, but no provision is made for payments toward past or future construction costs. Another city, having a population of 8,000, by payment of $57,000 toward acquisition of right-of-way, obtained a perpetual right to the discharge of an unlimited flow. Fourteen of these adjacent areas at this time contribute the sewage of 290,000 persons to the Hyperion screening plant. This number is more than 22% of the estimated 1,300,000 population within the City of Los Angeles tributary to Hyperion. Furthermore, a number of these communities are situated so that their percentage increases in population over the next few decades are likely to be quite spectacular, but unless some drastic modification of these contracts is brought about, it will be Los Angeles which will bear the cost of added capacities and facilities when these must be provided.

Topographically the area east and south of Los Angeles is not readily accessible to the Hyperion Outfall. The trunk sewers of the Los Angeles County Sanitation Districts flowing toward the Harbor, however, do serve this outside area advantageously; in fact, some of the southeastern area lying within the City is made tributary to Hyperion only by means of the Manchester pumping plant, although that area is in the natural drainage of the County system.

Population

The great indeterminate factor in the Los Angeles sewerage situation is the rate of population increase. After the census of 1930 revealed that Los Angeles had a population of 1,238,048, the *New York Herald-Tribune* editorialized on "Los Angeles, the Wonder City." No other city in history had experienced such an abrupt concentration of people within a generation and in a situation where precedents do not exist, those who are required to make forecasts of population are beset with the question: "To what extent will the future conform to the past?" The unique aspect of the local situation is that natural reproduction has been a minor factor in the total growth, while migration has and is likely to continue to account for a great proportion of population increments. Bearing on this condition, the following circumstances are significant:—

In 1900-10 L. A. Co. received, 1 out of 8 persons settling in 11 western states.
In 1910-20 " " " 2 " " 5 " " " " " " "
In 1920-30 " " " 1 " " 5 " " " " " " "

The Metropolitan Area increased from 30,000 to 2,318,000 in fifty years.

Population Growth of Los Angeles

Year	*Population*	*Increase*	*Percentage In Decade*
1930	1,231,730	655,057	114
1880	11,183		
1890	50,395	39,212	
1900	102,479	52,084	103
1910	319,198	216,719	211
1920	576,673	257,475	80
1930	1,231,730	655,057	114
1940			

While the World War temporarily interrupted the trend of population shift toward this region, prior to the census of 1920, that lag was overcome in the early years of the succeeding decade. The depression of the '30's likewise interrupted the transplanting of large numbers of persons possessing an economic competence although the number of tourists who may later wish to become residents has been reaching new totals. The possibility of war again causing a dislocation of population shifts must be recognized, but the industrial situation of the locality is radically different now than it was twenty years ago, and such a disturbance might not be so great as in the previous war. The fact that several of the largest aircraft factories in the country are located in areas tributary to Hyperion is significant in reference to immediate as well as long-range population changes.

CITY OF LOS ANGELES

Estimates of Population Growth

Prepared by the City Engineer

Year	*Population*	*Increase*	*Percentage For Decade*
1940	1,400,000	168,270	14
1950	1,950,000	550,000	39
1960	2,650,000	700,000	36
1970	3,400,000	750,000	28

It will be observed that the foregoing estimates of population of Los Angeles represent rates of increase substantially less than those which have occurred prior to the decade just closing.

As previously stated the estimated population in 1939 of the 14 communities, not a part of Los Angeles, which contributed sewage to Hyperion was 290,000, compared to 1,300,000 from within Los Angeles. On the basis of estimates that a population of 4,000,000 would be contributing to the North Outfall, its successor conduit and Hyperion in 1970, the division, it is believed, would be 3,180,000 from Los Angeles and 820,000 from the 14 outside communities.

The estimates in the above table are larger than a number of other similar estimates compiled during recent years and have been criticized because they involve a resumption of the previous trend after a 15 year sideways shift. The uncertainties are numerous and unpredictable as to occurrence and effect, so a dogmatic attitude is hardly justified. It may be stated with assurance, however, that both the sewers and the disposal facilities of Los Angeles are seriously in need of enlargement or replacement and this work can satisfactorily be undertaken on a progressive construction schedule.

Beach and Ocean Conditions

Following the installation of revolving drum type screens at Hyperion, on the old Central Outfall in 1924, and on the North Outfall as it went into service in 1925, the physical conditions on the adjacent beaches were much improved in contrast, but the actual hazards to health have remained and increased. The total removal of suspended solids is 3%, which allows over 200 tons of solids including 12 tons of grease to pass through the screens into the ocean every 24 hours. This filth drifts up or down the coast depending upon the direction of the current polluting some four miles of bathing beach. The State requirements for bathing beaches permit a B-Coli count of 10 per c.c. Samples taken at different times show Coli-Aerogenes counts of 100+ along a stretch of beach several miles in length. Leaks at the joints in the submarine discharge line, which persist in spite of repeated efforts to stop them, have contributed largely to the contamination of shore waters. The leakage through the defective joints is said to amount to 20% of the flow. The line is 7 ft. in diameter, is 5000 ft. long, and its design capacity was 450 cu. ft. sec. Due to drifted sand through the leaks and the end, its capacity is now believed to be reduced to about 300 cu. ft. sec.

As the flow at Hyperion continued, a progressive increase of approximately 15 cu. ft. sec. per year, there were times in rainy weather when flooding of

the screening plant was imminent. In 1933, a by-pass channel around the plant was built to accommodate the flow in excess of 300 cu. ft. sec. and discharge it upon the beach.

Quantity of Flow

The sewage flow of Los Angeles and the other communities tributary to the Hyperion plant is measured by a recording venturi meter just after it has passed thru the drum type screens. On the basis of the 1930 census the average flow represented 80.56 gals. per capita in 24 hours. For the fiscal year 1938-39 it was calculated that the average flow of 130,770,000 gals. at Hyperion was 82.24 gals. per capita in 24 hours. In consideration of the indicated trend toward slightly larger flows and making some allowance for increased flows from air conditioning installations, it is believed that 85 gals. would be a justifiable figure to use in future treatment plant design for per capita daily flow.

The dry weather peak daily flow at Hyperion is approximately 300 cu. ft. sec. During periods of very heavy rain such as is experienced about once in five years, the peak flow exceeds the 450 cu. ft. sec. capacity of the North Outfall sewer and causes it to flow under pressure and to overflow at several manholes elevated about five feet above the conduit.

This condition of surcharged flow during extremely heavy storms exists also in many portions of the city where sewage rises from manholes and spills into the gutters. One cause of this excess storm water in the sewers lies in the fact that there are many storm water inlets to the sanitary sewers in the City of Los Angeles and the contributing communities. These connections, some of which are contrary to City ordinances, comprise downspouts from roofs, yard drains, leaky manhole covers and direct storm water inlets in the streets.

Character of Sewage

The sewage of Los Angeles as represented by analyses of about fifty samples collected at random over a period of three years, is a typical domestic sewage except that the amount of suspended solids is relatively high. Its grease content is normal for California cities whose per capita sewage contribution is about the same as that in Los Angeles.

Approximate Character of Sewage as Received at Hyperion

Determination	Parts Per Million			Pounds Per Capita Per Day		
	Aver.	Max.	Min.	Aver.	Max.	Min.
Susp. Solids—Total	360	960	80(+)	0.24	0.65	0.05(+)
Susp. Solids, Volatile	300	760	80(—)	0.20	0.52	0.05(—)
Five Days B O D	260	420	100	0.18	0.29	0.07
Chlorides	290	530	210	0.20	0.36	0.14
pH	7.3	7.6	6.9			
H2S	10	10(+)	1.5			
Ether Soluble (Grease)	50	220	10	0.03	0.15	0.01

Physical Condition of Lines and Works

The Central Outfall, constructed in 1906, was built of brick. Deterioration caused by the presence of sceptic sewage resulted in nearly complete abandonment of the line soon after the North Outfall was put in service.

Portions of the line are in good condition, but it is estimated that an expenditure of about $250,000 will be needed to restore its capacity of 90 cu. ft. sec.

The North Outfall completed in 1925 is an unreinforced concrete conduit of horseshoe section lined with tile blocks having cement joints. The extreme inside width is 12¼ feet and the height is 10½ feet. This section is used on the final 8½ miles constructed on the minimum slope of 4 feet in 10,000. The structure of this outfall is in critical condition in two respects; one resulting from extended longitudinal cracks high up on the sides, and the other from disintegration of the interior. The hazard due to the cracks is particularly great since the line is occasionally subject to flow under pressure. Should a rupture occur, the consequent erosion might impair the sandy loam support of the whole structure for some distance. In recent years nearly one mile of the outfall line has been strengthened by the construction of a reinforced concrete blanket one foot thick over the sewer.

After about ten years of service it was observed that the tile liner blocks were spalling or falling into the line as a consequence of the hydrogen sulphide gas present in the damp sewer. The cement joints and subsequently the concrete itself were attacked by the acid forming gas. Ventilation of a section of this sewer has recently been effected by the installation of an exhaust fan of 22,000 cubic feet per minute capacity at a station located a short distance southwest of Centinella Avenue. The results have been very gratifying. The exposed interior surfaces of the sewer within the influence of the fan ventilation are now dry and further disintegration has apparently been arrested. An article entitled, "Experimental Ventilation of the North Outfall Sewer of the City of Los Angeles" by E. G. Studley, giving a comprehensive description of the installation and results is to be found in the Sewage Works Journal, Vol. XI, No. 2, March, 1939, pages 264-270.

Summary of Current Conditions

The beaches of Santa Monica Bay are among the most accessible recreational resources available to the people of Los Angeles and vicinity. For recreational purposes, therefore, these beaches and shore waters, if hygienically safe, have inestimable value. Since the time when the first outfall into the Bay was established at Hyperion many years ago, the adjacent beach and the shore waters have been grossly contaminated. The extent of this pollution has been such that significant portions of the beach have been unusable and have been under quarantine by the State Board of Health.

The North Outfall Sewer, for approximately one-half of the four mile section between Centinela Avenue and Del Rey, is in a critical structural condition with cracks along both sides. Moreover, disintegration of the interior surface has proceeded to an extent which must be regarded as serious. The line from Centinela Avenue to its terminal end at Hyperion is at times overloaded with storm water to the degree that overflow from manholes occurs during severe storms with consequent erosion of its earth cover. Such surcharges took place, for example, in January 1934, March 1938 and September 1939.

The submarine outfall at Hyperion, some 5000 feet long, is also in bad physical condition and for that reason its safe capacity is from 300 to 360 cubic feet per second, or from about 195 to 230 million gallons per 24 hours, depending upon tidal elevations, instead of 450 cubic feet per second, or

approximately 290 million gallons per 24 hours, for which it was designed. It is stated that the leakage through faulty joints along its length amounts to 20 per cent of its capacity.

Serious overloading of local trunk sewers occurs in many places throughout the city following heavy rains. Badly needed capacity for normal flow and growth is thus preempted.

Issues of the Present Situation

The sewerage facilities provided for and built under the 1922 bond issue of $12,000,000, although monumental in some respects, represent an interim expedient when considered in reference to the future of a large metropolis. The steps preliminary to providing additional outlets for the discharge of sewage or sewage effluent in addition to the single line to Hyperion, now overloaded and creating a combination of nuisance and menace, have yet to be taken. Other supplementary directions of disposal are available, but the delay in their development only afford opportunity for the accumulation of obstacles and resistance. The established right of the City of Los Angeles to discharge sewage into the ocean at Hyperion is an invaluable one, but its benefits could still be utilized in conjunction with a treatment plant of appropriate scope on the shore to correct the present bad conditions.

The physical condition of three important elements of the system presents emergency problems. An extension of the ventilating installation which has proven so effective, offers a demonstrated means of controlling disintegration inside the line and prolonging its life indefinitely. Strengthening of the conduit of the North Outfall by external reinforcement is critically needed to safeguard the structure from rupture and consequent flooding of adjacent territory. Even if the conduit is so strengthened it should not then be subject to flow under pressure. To guard against that circumstance, and automatic overflow gate to function when normal capacity is reached, has been proposed at the point in the line where it is but a few hundred feet from Ballona Creek. At such flood times the storm runoff in the Creek would provide generous dilution. In March, 1938, the flow in Ballona Creek reached 19,000 cu. ft. sec.

Second: The restoration to service of the unused Central Outfall would add 90 cu. ft. sec. much needed capacity for present and future flow to Hyperion. It is estimated that an expenditure of $250,000 would place the line in first class condition.

Third: The present restricted capacity of the submarine discharge line is approximately 300 cu. ft. sec., which is no more than the dry weather daily peak flow. A condition exists requiring early connection by construction of another discharge line, its size dependent upon the proportion of the total flow of the system which will be determined to be destined for Hyperion.

A pertinent question is whether present investigation of the City's sewerage system should involve an approximate limit to the volume of sewage which can be permanently discharged into the ocean at Hyperion without recreating conditions which it is now hoped to abolish. Such a limitation of volume at Hyperion as well as consideration of the cost of conveying increased flows 20 miles or more to the ocean make the possibility of providing inland treatment plants at advantageout locations particularly significant.

The conservation aspects of sewage treatment aside from the reclamation

of the beach frontage—which represents conservation of the highest order—would involve the by-products of water, fertilizer and fuel gas. It is possible that these elements may attain importance at some future time. Under immediate prospects the only locality where highly treated effluent could be conserved would be in an area where percolation of the water would take place readily. By losing identity as effluent and augmenting ground water reserves, a general benefit would result.

Due to the existence of an impervious clay "blanket" overlying the coastal plain southerly from Vernon and Maywood and westerly from Inglewood and Culver City, spreading of water for percolation into the ground is not feasible in that area. A plant located on any site near the Los Angeles River somewhere between Van Nuys and Universal City would be advantageously situated for spreading of highly treated effluent upon porous areas and would release a moderate amount of sewer capacity for utilization further on.

A treatment plant located southeasterly of Los Angeles in proximity to the River could be made the destination of all that flow in the North Outfall originating above the Enterprise Street Crossing of the River where the line turns westerly toward the Sea. The diversion from the sewer of the already stale sewage would not only reduce the volume, but would have a beneficial effect on the remaining 22 miles of conduit with consequent prolongation of its life. The requirement of this River plant would be mainly to produce an effluent sufficiently stable and of a standard that its addition to the system would not constitute a detriment to the quality of the flowing water.

Subsequent increase in flow and the necessity for limiting the discharge at Hyperion may create an urgent need for a treatment plant adjacent to the Baldwin Hills so situated that a high grade effluent might be discharged into Ballona Flood Channel.

The requirements of treatment plant sites are such that their early selection and initial use are of vital public interest. Availability of an advantageous site should be utilized in advance of extreme need. The sites should be acquired and sufficient works installed to establish the right to operate, and the opportunity used to demonstrate that freedom from unpleasant and detrimental effects is possible and may be expected.

Los Angeles is now confronted with a sewerage situation which has become increasingly acute during recent years. The opportunity is available to undertake a comprehensive plan of improvement which will be adapted to the unique and diverse conditions existing in and adjacent to the City and toward which steps may be made progressively as the sequence of work is determined and funds are provided.

Discussion:

Mr: Charles Gilman Hyde, University of California, Berkeley:

Professor Thomas has presented a very illuminating and adequate review of the trunk sewerage and sewage disposal situation of the City of Los Angeles and its tributary environs. There seems to be little or nothing to add unless it be with reference to the matters of adequacy of provision for future sewage quantities and the cost of treatment and disposal works so involved.

It has been made apparent that there is no single or simple solution of the problem of sewage treatment and disposal for this great metropolitan area. Several solutions are physically and economically feasible and may be argued to be logical. The decision, evidently, cannot be made on the basis if cost alone. The

influencing factors are too numerous and too diverse. These factors are psychological and esthetic, as well as technical and financial.

Man has not developed into a prescient animal. As to the past he may have a definite presbyopia but as to the future he is decidedly myopic. Such important things as the determination of the population which must be provided for during the next 30 or 40 years, the cost of money (i.e., the interest rate), the unit costs of construction (i. e., the commodity and labor cost levels), and other significant factors man is unable to forecast with any degree of assurance.

Under the circumstances the wisest program to advocate would seem to be one which will make very ample provision at the outset for all reasonable contingencies. It is an agreeable circumstance, all too seldom realized, to find that the estimates of costs, both of construction and of operation, have been too generous rather than too meager. It is better to have adequate funds with which to build and operate in the best way rather than to discover that the estimates, and therefore the monies available, are insufficient to meet the controlling conditions with maximum effectiveness.

Lands in particular should be immediately acquired in generous areas at logical treatment and disposal plant sites. Excess land holdings can always be sold in future if unwanted. This may generally be done at a premium as compared with purchase values at an earlier date. The truth of this assertion lies in the fact that lands, in general, are appreciating in value within the Los Angeles metropolitan district and will doubtless continue to increase in value for years to come, or until the population density in any given area becomes fixed. On the other hand, it is obvious that lands once put to other intensive use can be obtained only with difficulty and generally at exhorbitant cost.

Treatment and disposal works should be designed of such flexibility as related to expansion that their capacity may be increased from time to time as conditions dictate. While this statement is partially true with respect to main conduits (trunk sewers), also, it has less effect here and all such lines should probably be constructed of generous proportions at the outset. The present worth of additional capacity in terms of cross-sectional area is apt to be less than the delayed cost of additional conduit lines, unless such delay is measured in terms of a considerable span of years and/or interest rates are high.

Of the three general projects recently studied and reported upon by the Board of Consulting Engineers, the one which seems to have the greatest merit makes provision for the next three or four decades with a minimum of immediate expenditure. It provides for extensions and additions when such become necessary and defers their construction to the time. Although the annual costs over a 30-year period have been figured with capital expenditures assumed to be made only at the beginning and after 15 years, in the actual case a program of development should be devised which will provide for main sewerage and for sewage treatment and disposal when and as needed.

The project proposes to test the capacity of Santa Monica Bay in the vicinity of Hyperion to receive, without adverse shore pollutional effects, an adequately pretreated sewage and to limit in the beginning the volume of sewage thus treated to one which appears to be logical and safe.

The cost figures for inland treatment works have been set sufficiently high, it is believed, to provide liberally for land areas affording relatively wide buffer strips around the works, landscaped to create parks available for receational purposes. The funds are proposed to be sufficient to permit of fine architectural treatment of all exposed structures and to control odors to the point of virtual elimination. The Board if Consulting Engineers feels that such demands are worthy of being satisfied even at considerable expense and that no solution of the problem will be satisfactory unless all such esthetic requirements are fully met.



POLLUTION CONTROL WORK OF THE CALIFORNIA STATE DIVISION OF FISH AND GAME

By **PAUL A. SHAW**

State Division of Fish and Game

Papers by Howard Vernon (1) and Colonel Kelton (2), presented at the last meeting of the California Sewage Works Association, together with Mr. Rawn's discussion of the latter (3), served to indicate California's growing interest in the problem of pollution control. Since both speakers mentioned pollution activities of the Division of Fish and Game, it may be of interest to extend the series; it is therefore the purpose of this paper to describe more fully the work of our Pollution Detail. First, however, it would appear desirable to discuss the legal status of pollution control in California in order to have a clearer picture of the situation.

LEGAL STATUS IN CALIFORNIA

In California, since no interstate compacts exist, we are limited to three of the four control methods pointed out by the National Resources Committee (4) and further discussed at the last meeting of this Association. These are:

1. Enforcement of Federal Laws.
2. Enforcement of State Laws.
3. Injunction or private damage suits.

Federal Law

Under Federal Law, where navigable waters may be affected, action can be taken to prohibit the discharge of oil from vessels and to prohibit the discharge of refuse from vessels or shore plants, exclusive of that flowing from streets and sewers in a liquid form. While it has been indicated that Federal jurisdiction is very limited, this support has been most valuable to our Pollution Detail in reducing harbor and coastal pollution. The cooperative enforcement work with the U. S. Engineers, U. S. Customs, and U. S. Coast Guard, described in Colonel Kelton's paper and by Shaw and Towers in a previous illustrated bulletin (5) was initiated largely through the efforts of Warden C. L. Towers, who was assigned to our pollution work in 1935. Since that time an active Federal program on pollution enforcement has spread to the East Coast and other ports following the transfer of officers who became familiar with the work of our Pollution Detail in California.

In addition to the Federal jurisdiction just described, certain Federal restrictions on hydraulic mining debris in the Sacramento River watershed are in force. In this connection, due to the rapid growth of gold dredging operations, many of which have a daily capacity of several thousand tons, it is unfortunate that regulations of the California Debris Commission have not been modified to include the control of silt from this source.

State Laws

In this State the Public Health Act and Section 481 of the Fish and Game Code are the principal statutes providing means of pollution control. The Public Health Act restricts the pollution control work of the State

Department of Public Health and local health districts to those conditions which are shown to be a nuisance or menace to health. While this Act embodies an elaborate permit system and provides for an adequate technical staff, it is weak in enforcement features and consequently raw sewage is still discharged from many municipalities that have knowingly escaped restriction by failure to request a permit.

The Fish and Game Act, except for certain named substances, restricts pollution control to those conditions deleterious to fish, plant life, or bird life. This section is strong to the extent that proof of damage is not essential for items such as petroleum, acid, sawdust, and certain types of factory refuse that are specifically named in the section.

While it is logical that health laws should only control pollution from the standpoint of health and fish and game laws only from the angle of aquatic life, the unfortunate situation is created that neither agency can act on justified complaints when the damage is to agricultural, industrial, or recreational uses. In instances of this type, injunction proceedings or damage suits constitute the only remaining recourse.

Notwithstanding the limited scope of our fish and game section, we feel that much has been accomplished in the past few years by the Pollution Detail towards eliminating severe sources of pollution. Many conditions not fully covered by law have been corrected through cooperative work, and remedies effected for conservation of aquatic life have been beneficial from the standpoint of other water uses.

CONTROL OF WASTE DISPOSAL

Petroleum Products

Losses of oil in harbor and coastal areas from ships and vessels, occurring during the loading of oil at terminals, from broken lines, overflow of tanks, or through the pumping of oily bilge, have constituted a severe source of pollution in the past. Active enforcement work of the Detail in cooperation with Federal authorities has reduced this source to a minimum, but constant patrol efforts must be maintained to prevent careless practices being renewed.

At shore plants such as oil refineries, and wells, manufacturing establishments, railroad round houses, etc.; insistence on adequate separating and skimming devices, properly constructed sumps and clean-ups in case of accidental spills has all served to reduce former sources of oil pollution. The improvement has been particularly marked at the round-houses, car washing and oil loading stations of the railroad companies.

In certain oil fields, in addition to separation of oil from the waste water, studies are now under way to eliminate sulphide compounds and suspended solids which have created serious degrees of pollution in coastal areas. In one southern California field where research has been in progress for over two years, following insistence by our Detail, an appropriation of approximately $120,000 is being provided for installation of a complete treatment plant.

Mining

Due to the increased price of gold, there has been a large expansion of mining activities in the past few years. This applies to all types of mining.

The spent ore from milling operations is extremely deleterious to fish life

and this material also covers stream beds, preventing the growth of food organisms and development of spawn.

Through the work of our Pollution Detail, many mills have installed impounding areas where the tailings are stacked and the settled effluent is then discharged to State waters. In certain areas impounding is still a seasonal matter, the tailings being permitted to wash out during storm periods. Definite progress is being made, however, looking toward permanent impounding of all mill tailings.

As previously mentioned, gold dredging operations constitute a severe source of pollution that is not controlled by the California Debris Commission. At the present time about 165 such operations are in progress in the northern part of the State. Proof of damage to fish life is difficult with silt of this type and damage to other interests is probably greater than that to aquatic life. Despite this fact, improvements have been effected in many instances through cooperative efforts. In general, for dredging operations, we request adequate settling ponds and by-passing of the normal stream flow. In this connection our laboratory found that proper dosages of lime and alum would flocculate the collodial clay particles satisfactorily and a number of operators have utilized this procedure for clarification of dredge tailings. Recommendations for chemical treatment of dredge tailings were published in Mining and Industrial News for December 15, 1938.

Hydraulic mining is being renewed following construction of debris dams by the Federal Government. These dams are designed to prevent debris reaching the valley areas where it would constitute a menace to navigation. It is apparent that the recreational public is not sympathetic to the renewal of hydraulic operations since tailings pollute streams for many miles between the mining operations and the debris dam. In addition, the dams only settle out the heavier material and muddy effluents have caused many complaints. In one instance an injunction was recently secured against a hydraulic operation for pollution of a municipal supply below the debris dam.

With the renewal of mining, it has been necessary to pump out many old tunnel shafts. Such waters may be high in acid and metals deleterious to fish life. The pumping of one tunnel resulted in the death of fish sixty miles down stream. Immediate action was taken to prevent further drainage; the tunnel water was impounded and has now evaporated to a large extent making the mineral content available for recovery.

A severe condition of tunnel drainage exists in the area above the Shasta Dam, now under construction. While the drainage from these abandoned copper mines may not seriously affect the Sacramento River, it is felt that damage will occur following completion of the reservoir, since narrow arms of the reservoir will fill with water of sufficient acid and copper content to prevent the development of any aquatic life. A complete study of this matter is in progress and a Federal project may be requested to seal the tunnels, thus preventing access of air and further oxidization and solution of the ore.

Food and Beverage Wastes

At a previous meeting of this Association, the writer presented a paper (6) covering studies on winery wastes and indicated that disposal of still slops to the Mokelumne River had been prohibited. The following year one

winery developed a treatment method using lime and a trickling filter which appeared to give excellent purification.

Unfortunately the 1938 winery season occurred during an election period and due to pressure brought by certain interests, our enforcement program was dropped and further research work by the industry was discontinued. In 1939, due to low stream flows, the situation in the Mokelumne River became serious soon after the winery season opened and salmon, bass, perch, and other species of fish were killed for many miles below the winery outlets. Immediate action was then taken to enforce the law and two weeks later the wastes were being disposed of in sumps or on land. The river cleared rapidly and the remainder of the salmon run continued up stream to spawning grounds. No further disposal of untreated waste to the River will be permitted and we understand that one winery anticipates installation of a complete treatment plant along the lines previously worked out. It is indeed unfortunate that conditions must at times reach such a critical state before remedial action can be enforced.

In the San Joaquin delta, where celery packing for the eastern market is concentrated, a waste collecting plant costing $30,000 to $50,000 was completed last year, following a two year program to have this condition corrected. Waste from this source, totaling 30-35% of the celery received from the field, was formerly discharged to the river. The installation includes a 1700 foot flume into which water is pumped to float the waste from twelve concerns to a central point. It is then picked up by a belt conveyor discharging to a large bin under which trucks are driven for loading. Floating by means of a flume eliminated the necessity of installing individual conveyors for each packing company in the shed. It is our understanding that the packers now receive 50 cents a ton for this waste and that it is resold as cattle feed by the trucking concern for $2.50 per ton.

A severe degree of pollution from fruit and vegetable canning wastes has existed in the valley and bay area for many years, the principal products being asparagus, peaches, and tomatoes. Solid wastes have been discharged direct to State waters or passed through grinding machines and discharged to State waters through city sewers. Instructions were issued to individual canners and the Canners League of California in 1938 to discontinue this practice; the restrictions covering only waste that could be removed as garbage like material. A number of small canneries complied with these regulations in 1939 but the larger concerns while appearing cooperative, failed to take definite remedial steps. For 1940, through an agreement with the Canners League, all plants are required to dispose of one-third of the waste by other means than discharge to State waters. By the following year, pollution from this type of waste should be practically eliminated. Additional surveys will then be undertaken to determine whether the remaining soluble components in cannery wastes cause a sufficient oxygen depletion to necessitate further restrictions.

Fish canning and reduction in the San Pedro, Monterey and San Francisco areas has been a source of pollution for many years. Through the efforts of our Pollution Detail many firms have now installed screens and settling tanks which remove a large portion of the suspended solids. These are added to meal production and have thus added to the revenue. The bilge water from purse-seine boats, which contains about two per cent sus-

pended solids, is now pumped into the plants at San Pedro and Monterey and passes through the screens and settling tanks provided. A similar method will be employed in the San Francisco area this coming season.

The principal pollution load from the fishing industry is the waste, known as "stick water," remaining after removal of fish oil and meal in the reduction process. This waste contains about six per cent organic matter, high in protein and vitamin content, and should be profitable if an economical recovery method is developed. At least three concerns have studied this problem and our own laboratory has shown that pollution from this source can be reduced about 70% through a coagulation process utilizing sulfuric acid. In view of this work instructions have recently been issued that equipment must be provided at the beginning of the August season to materially reduce pollution from this source. Analyses of stick-water have shown that pollution from this source on peak fishing days in the San Francisco Bay area is equivalent to the raw sewage from a population of 5,000,000.

Sugar refineries have been another source of waste, causing damage to fish life in several California areas. However, we have generally secured good cooperation from plant operators, and disposal on land or by discharge following settling and lime removal, where adequate dilution is available, has generally proven satisfactory. One plant where adjacent land owners have objected to land disposal is now installing a treatment unit. Another plant will impound concentrated wastes this coming season, the remainder being discharged direct to the ocean.

Miscellaneous Waste Products

At various saw mills, chemical plants and manufacturing concerns throughout the State many improvements have been effected where wastes formerly polluted our streams. These will not be described, however, since the foregoing material is sufficient to indicate the work being done by our Detail.

PERSONNEL AND OPERATION OF THE POLLUTION DETAIL

Before concluding, it may be of interest to indicate, briefly, the organization and method of operation of our Pollution Detail.

The personnel is composed of technically trained men working under the budget of the Bureau of Fish Conservation and Patrol Officers assigned to the unit from the Bureau of Patrol, the total number varying from 8-10 men. The cooperation of all other field men of the Division of Fish and Game is solicited, to render prompt notice on any pollution violation or condition requiring attention, but instructions have been issued not to file cases or recommend remedial measures since the work is specialized and must be handled uniformly.

We believe that our success to date is the result of proper correlation of technical, cooperative and enforcement work, the desire being to correct conditions rather than to emphasize court fines. Notwithstanding this policy 210 cases with fines totaling $35,265.00 have been prosecuted under the efficient supervision of Mr. Towers during the past five years. No case is brought into court without a full written report, together with samples, photographs, and analyses if needed. When the pollutant is not fully cov-

ered by law, stream surveys and complete technical data are secured, in most instances the condition then being corrected by request.

Conclusion

From the work that has been done we know that aquatic and recreational conditions in many areas have improved to a marked degree, but the work is far from complete. Years will be required to eliminate many polluted areas, and even then constant effort will be required to maintain and protect State waters from potential sources of pollution.

In conclusion, the writer wishes to express the opinion that a central state agency or advisory board for pollution control may later be advisable. This belief is based on the trend of legislation elsewhere, on the limited scope of both the Health Law and our own law, and on the right of the people to refer complaints to an agency with statute authority to act from all standpoints of water use, including agricultural, industrial and recreational value. Such a set-up would eliminate the just criticism of discrimination when we expect industry to correct conditions while a line carrying raw sewage is permitted nearby. Further, industries, municipalities, consulting engineers and equipment firms would then be assured that the requirements of one agency are final and that procedures recommended by one agency are not going to be frowned on by another.

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COVINA SEWAGE TREATMENT PLANT

By ADOLF H. KOEBIG, JR.

Of Koebig & Koebig, Consulting Engineers

The Covina Sewage Treatment Plant embodies a high degree of treatment for the sewage of a small city using both biological and chemical treatment processes. It is the purpose of this paper to present the difficulties encountered in the building of this plant and to show how these difficulties were overcome by design and operation.

In order to understand how local conditions and public sentiment controlled the design of this plant we must review the history of sewerage in the City of Covina.

History

Covina is a sixth class city incorporated in 1901, is located in an orange belt 22 miles east of Los Angeles, and has an area of one square mile. The estimated population in 1939 was 3200 inhabitants. It is bounded on the west and south by West Covina and on the north and east by County territory.

In 1920 there was a great deal of agitation and promotion in the cities in this vicinity to form a sanitary district and join with the County of Los Angeles. Although the City of Covina favored the formation of such a district by a vote of two to one, the issue was defeated on the other cities. In 1923 the citizens voted bonds for the construction of a sewer system at which time many sewer mains and laterals were laid in the city but an attempt to secure disposal facilities was unsuccessful.

The City Council attempted four times during this period to dispose of their sewage, without success. The city owned a 100-acre tract of land five miles to the west near Baldwin Park but a permit from the State Board of Health could not be obtained due to the fact that the people in Baldwin Park objected to having Covina sewage in their vicinity. Another disposal site was selected in an agricultural area to the southwest, lying in the County, which was contested by the City of West Covina.

During this entire time the Los Angeles County Health Department and the State Board of Health continuously complained about sewage disposal in the city by means of cesspools and warned the city that the existing sanitary conditions were a menace to the health of its citizens.

The only locations available to the city for a sewage disposal site were to the north, northeast and southwest in County territory. As the gravity flow is toward the southwest, the sites to the north and northeast were prohibitive on account of the high pumping costs. The city found itself with a sewer system practically completed but without disposal facilities that would satisfy its neighbors. It was decided that if they wanted to complete their sewer system they would have to select a site within their own corporate limits.

Finally a ten-acre orange grove with full grown trees at the southwest corner of the city was purchased and annexed to Covina. Opposition of nearby growers and local citizens to the proposed construction of a plant on

this site was bitter. However, in spite of this opposition ,in June, 1939, the citizens voted $60,000 of bonds by a two-thirds majority and procured an allotment from the P.W.A. of $49,909.

The scope of this project included construction of treatment plant, influent and outfall lines, sewer lines in the business area of the city that had not heretofore been constructed, and wells for underground disposal of effluent.

The plant design was governed by requirements for:

1. Odor control.
2. Sewage to be treated to a high degree of stability to allow percolation in underground wells without contamination.
3. Flexibility of treatment as primary, secondary and complete treatment.
4. Good sludge digestion conditions.

To comply with these requirements the Engineers selected a design using two-stage biological treatment with flexibility of individual units, chemical flocculation, rapid sand filtration, sterilization of effluent, odor control and two-stage sludge digestion.

Before construction started persons living in the vicinity of the site filed an injunction case against the proposed plant construction, their contentions being founded on the following grounds:

1. That obnoxious and offensive odors would be given off from said plant to the injury of adjoining properties in this area.
2. That depreciation in value of their properties and of others similarly situated would result.
3. That boron from orange packing plants and laundry would be deposited in the sewer lines and would percolate into the underground water system contaminating their nearby water wells and injuring their orange trees. Also that the wells would be spoiled for domestic use by harmful bacteria in said waters.
4. That the proposed plant was inadequate to take care of the present or future needs of the community and the site was unfitted and not adaptable to the proper percolation of waters through the soil. That the plant would create an unsanitary and unhealthy condition. That the cost of maintenance of plant would be exorbitant and that the plant would not be operated by skilled employees.

Trial of this case, namely, "W. C. King, et al., vs. City of Covina, Case No. 432033 of Superior Court," was started on September 28, 1938. The finding of the Court was that no nuisance had been created, but on the grounds of "Haskell vs. The City and County of San Francisco, Case No. San Francisco 15209," the Court sustained the injunction against possible nuisance. This case was set for trial and all the defendants were represented by Mr. Dailey Stafford, City Attorney of Covina, who was aided in the trial of the case by Mr. Ray Goudy, Consulting Bacteriologist, and Mr. Adolf H. Koebig, Jr., Consulting Engineer.

After all the evidence had ben submitted by the plaintiffs and defendants the Court made the following findings:

> "That the public health of the people of the City of Covina requires, and there is an immediate necessity for, the construction of a sanitary sewage disposal plant.
>
> "That plans and specifications of the City of Covina referred to by plaintiffs herein are adequate for the purpose intended."

These findings were borne out by proof of the following facts:

1. Odors would be absolutely controlled throughout the plant.
2. Construction of the plant in the middle of the orange grove would be remote, and unseen by nearby residents.

3. That sewage treatment and operation of proposed plant would be successful for many years to come.
4. That an ordinance would be provided by the city to prevent packing houses from disposing their waste into the sewer system.

Construction work was started in November, 1938, and completed in May, 1939. Following acceptance of the plant by the City, sewer lines were laid in alleys in the business area. Cast iron pipe was used so as to span across the numerous cesspools.

Description of Plant

Covina sewage is mostly domestic, plus laundry waste. Design features of the plant were based upon the present population of 3200 and a future population of 5000 estimated to produce a maximum flow of 500,000 gallons per day.

The treatment used at Covina might be described as a combination sewage and water treatment process. The treatment process is designed for gravity flow wherever possible and still maintain a high elevation to provide a gravity flow of effluent to any part of the orchard. Treatment consists of screening, pumping to primary clarifier, gravity flow to the primary rock filter and then to recirculation pump pit. Here the flow is divided by weirs, a portion is pumped back into the primary clarifier and the other portion lifted into the secondary clarifier. Effluent from this tank is further divided into two flows. One portion is dosed with ferric chloride and flows by gravity into the combination flocculating and clarifying tank, while the other portion is discharged into the secondary rock filter and then recirculated back to the secondary clarifier.

Overflow from the clarifier-flocculator tank passes through two rapid sand filters, followed by chlorination, with final disposal to the orchard for irrigation or into underground percolating wells.

Application of ferrous chloride is possible at several vital points for odor control.

Sludge from all clarifiers is pumped to 2-stage digestion tanks. The primary tank is equipped with a stationary cover and a mixer, while the secondary tank has a floating cover for gas storage. Neither tank is heated at the present time. Supernatant liquor is drawn off the secondary tank and returned to either the pump pit or sludge beds. Digested sludge is drawn off to open sludge beds.

The main operating building houses the raw sewage wet well, dry pump pit, and backwash water storage well in the understructure. A stairway and platform in the wet well enables cleaning of the bar screen. Chemical lines run to this pit for chlorine or ferrous chloride application to the raw sewage, supernatant liquor return, and secondary and final sludge returns.

Pumps and manifolds are located in the dry pit. Sewage is handled by two 350 GPM constant and variable speed horizontal, centrifugal sewage pumps, float control mechanism and distribution manifold to any of the three clarifiers. Sludge from these tanks is carried through a manifold to two sludge pumps, one a 4″ Screw Impeller type and the other a 4″ horizontal, centrifugal sludge pump. Filter back-washing is done by a 750 GPM horizontal, centrifugal water pump.

On the ground floor of this operating building there is a small, well equipped laboratory, tool room, toilet and shower, an exhaust fan from both pits, an enclosed switchboard room and an incinerator on the southside for burning screenings, using either industrial or sludge gas. All electrical fixtures in this building were made explosion proof upon request of the State Industrial Accident Commission.

The recirculation pump pit consists of a collecting channel, weirs, and three interconnected pump pits. Three vertical, centrifugal low head water pumps lift the filter effluents into either primary or secondary clarifiers. Two of these pumps are variable speed while a constant speed pump serves as a standby.

Sterilization, odor control and flocculation are done with chlorine, ferrous chloride and ferric chloride, the latter two chemicals being generated in a Scott-Darcy unit. These units are flexible so that any of these solutions can be applied at several vital points in the plant. Final effluent is sterilized by a separate chlorinator as a protective measure.

Design Data

Population	3200	5000
Flows	0.32 MGD	0.50 MGD

Present flow assumptions not expected to be reached before 1948.

RAW SEWAGE PUMP PIT:
- 1—50 to 350 GPM variable speed pump.
- 1—350 GPM standby pump.

PRIMARY AND SECONDARY CLARIFIERS:
- Size each 35′ diam. x 8′ side water depth.

Capacity 61,000 gallons.

Detention when circulating twice the maximum design flow @ 0.5 MGD (1.5 MGD total) 1.0 hrs. Overflow rate 570 gallons per lin. ft. per hr.

PRIMARY & SECONDARY FILTERS:
- Size each 60′ diam. x 3′ rock depth.
- Area 2808 sq. ft. = 0.0644 acres.
- Quantity filter media 312 cu. yds.
- Dosing rate each 1.0 MGD (twice through filter) = 7.8 mg/ac/day applied load.
- Size filter media primary 1½″ to 2½″.
- " " " secondary ¾″ to 1″.

Estimated B O D applied to filters	625	lbs. per day
" " " " in final filter effluent	62	" " "
" " " " removed by filters	563	" " "
" " " " removed per cu. yd. filter	0.9	" " "
" " " " removed per acre ft. filter	1460	" " "

RECIRCULATION PUMPS:
- Primary 1—200 to 500 GPM variable speed.
- Secondary 1—300 to 750 GPM " "
- Standby 1—500 GPM

CLARIFIER-FLOCCULATOR:
- Size flocculation compartment 16′ diam. x 6′ deep.
- ½ hr. flocculation period @ 0.5 MGD.
- Size settling compartment 30′ diam. x 8′ deep.
- 2 hr. detention period.

RAPID SAND FILTERS:
- 2—8′ diam. sand filters each having area of 50.26 sq. ft.
- Design filtration rate 0.7 gallons per sq. ft. per minute.
- Backwash water pit capacity 15,000 gallons.
- Backwash rate 15 gallons per sq. ft. per minute.
- Pumping rate 750 GPM.
- Waste backwash water is dumped into sewer.

DRAINAGE WELLS:
3—size 6′ diam. x 65′ average depth 35′ above first water plane.
Logs show sandy loam, sand and gravel encountered with intermittent clay and sand stratas.
Each well designed for capacity of 35,000 gallons per day.

CHEMICAL HOUSE:
1—Vacuum type Solution Feed Chlorinator for sterilization of final effluent—Capacity 40 lbs.
1—Universal type Chlorinator and Scott-Darcy apparatus—Capacity 125 lbs. chlorine for manufacturing ferrous chloride, ferric chloride and chlorine.

PRIMARY & SECONDARY SLUDGE DIGESTERS:
Size each 30′ diam. x 20′ side—hopper bottom.
Total detention time 80 days.
Total effective digestion volume 26,140 cu. ft.
Digestion allowance per capita design population 5.23 cu. ft.
Estimated daily gas production 1.0 cu. ft. per capita.

SLUDGE BEDS
Area 3500 sq. ft.
Per capita design population 0.70 sq. ft.

Plant Operation

Operating results at Covina have been interesting over the short period of less than a year. To date there are about 150 connections out of a present possible 1000, but one of these connections being a laundry, a waste is provided which requires the complete plant to be run in order to provide the required effluent. Design capacities therefore have not been reached. However, due to the existing long detention periods in the tanks it is expected that by the time the design capacity is reached even greater improvement on the effluent may be expected.

One of the most serious objections to construction of the plant in its preliminary stages, as discussed heretofore, was the problem of odor nuisance. It is interesting to note the absence of objectionable odors at the plant. This can be attributed to several reasons:—

1. Absolute odor control at any point.
2. Short detention period in outfall sewer to plant.
3. Small sewage flow with dilution into oxidized sewage.
4. Quick and positive removal of sludges from all settling tanks.
5. Efficiency of operation.

Sewage flow to date has been small, averaging between 50,000 and 70,000 gallons per day. The amount of waste treated is greater as an average of 15,000 gallons per day of backwash water waste has been added to the raw sewage to be treated.

Close check on plant results has been kept by the operator. So far operation of the plant has been directed toward obtaining a perfect final effluent as to both appearance and stability with no series of checks on efficiency of individual units. It was thought at first that the entire plant would not have to be run, but due to the heavy load of laundry waste almost continuous operation of the complete plant is required.

So far it has been difficult to entirely remove the turbidity of the laundry water without final flocculation and filtration, at least to a standard which has been established by this plant for disposal into drainage wells. A few tests have been run, however, to try and show the degree of treatment in each

stage of the plant. The following table shows the average B O D of raw sewage and effluent per month:

	B O D Raw	*B O D Effluent*	*raw sewage lbs. per day*
November	220 ppm	5 ppm	1600
December	330 "	7 "	2600
January	241 "	5 "	1880
February	430 "	4 "	3530
March	681 "	5 "	

Results taken during the months of January and February alone gave:

Average raw sewage B O D	220 ppm
Primary clarifier effluent B O D	55 "
Secondary " " " " "	21 "
Plant effluent " " " "	5 "

Due to recirculation of filter effluent at a rate of 2.4 to 1 in the primary stage, the primary clarifier effluent included one part of primary settled sewage and 2.4 parts of partially oxidized sewage. Similar comparison can be made in secondary stage except that the recirculating rate has been about 3 to 1. The above results show a reduction between the secondary stage and the plant effluent from 21 ppm to 5 ppm B O D which is obtained by flocculation with ferric chloride, sedimentation and sand filtration.

Another comparison of plant reduction can be shown from turbidities (using Jackson Turbidimeter) as follows:

	Turbidity numbers Without laundry waste	*With laundry waste*
Raw Sewage	800	500
Primary clarifier effluent	51	133
Primary filter effluent	28	38
Secondary filter effluent	under 25	under 25
Secondary clarifier "	" "	" "
Flocculator effluent	" "	" "

(catch samples used)

The dissolved oxygen content throughout the plant has been checked as follows:

Primary clarifier effluent	2.3 ppm
Primary filter "	4.5 "
Secondary filter "	7.6 "
Flocculator "	7.0 "
Plant effluent "	7.6 "

Suspended solids have not been accurately tested during plant operation as this test has been of little value past the primary clarifier stage. It is estimated from a few tests that the average strength of raw sewage is about 300 ppm.

In spite of the dilution in the settling tanks due to recirculation, the primary tank has to take a large load of settleable solids since sludges from the secondary clarifier and flocculator are returned to the pump pit and mixed with raw sewage.

Sludge is pumped from the primary clarifier at short intervals with a short pumping period, thereby allowing a thick sludge to be removed. The horizontal, centrifugal sludge pump with variable speed control and the short pumping period have been large factors in successful removal of the heavy sludge. Scum is pumped to the digester through a separate system and pump.

During the six months that operation has been recorded the percentage

of moisture of raw sludge has varied considerably but has averaged about 95%. The system of sludge pumping has enabled a sludge of moisture content from 90% to 92% to be pumped with success, but operating experience has found that keeping the moisture of the sludge about 95% tends to hold the scum off the clarifier surface.

Operation of the two digesters was started by filling both tanks with water and adding sludge daily. This method eliminated both foaming troubles and also a high initial gas production, and did not require seed sludge. The table below gives monthly averages of tests at the digester tanks.

Month	cu. ft. day Gas. prod.	Raw	Prim. PH	Sec.	Prim. Temp. °F.	Sec.	Raw sludge % Moisture	Raw	Prim. % Volatile Matter	Sec.
November .	1026	6.8	6.9	6.9	69.6	67.6	96.0	56.5	28.2	24.7
December .	1200	6.5	6.8	6.8	64.6	63.4	95.7	62	34	24
January . .	1230	6.6	6.8	6.8	61.6	59.0	92.4	47	29	25
February . .	1390	6.8	6.9	6.8	60.6	57.2	95.5	50.5	41	32.5
March	1680	6.9	6.9	6.8	65.8	61.0	95.3	65	24.6	37.5

It is interesting to note the steady increase of gas production since November. Very little of this increase can be attributed to an increasing load on the plant as very few additional connections to the system have been made in the last few months. It might be attributed to increasing temperatures during Spring months and to increasing efficiency of digestion. This gas is metered and burned.

Due to the small flow through the plant the design rate of flow through the sand filters has not been reached. For smooth operation so far, each filter is backwashed about once a day and therefore it may be said that this filtration rate is 0.5 gallons per square foot per minute. However, this figure cannot be assumed as a maximum rate. During laundry period a lighter flow is formed thereby causing a much greater load to be removed at the sand filters.

A check of the operating records shows that the effluent has been used for irrigation about two thirds of the time. The effluent flows into the existing irrigation system for distribution.

The percolation wells average 65 feet in depth and are lined with leaching brick. The estimated percolation rate from each well was designed for 44 gallons per sq. ft. per day, but during the time that the wells have been used this rate has averaged 60 gallons per sq. ft. per day. The water level has not exceeded 20 feet off the bottom.

The Covina plant is operated under the supervision of the Water Department and is run very efficiently by one operator, Mr. Verner C. Johnson, with the aid of a part time relief operator.

This plant has proven that sewage plants can be built to provide a complete degree of treatment without being a public nuisance and can be operated at a very economical cost.

Discussion:

Covina Sewage Treatment Plant

By R. F. Goudey, Sanitary Engineer, Bureau of Water Works and Supply, Los Angeles

The City of Covina voted a sewer bond issue of $70,000 in 1914 and had to wait until 1940 before its sewerage works facilities were completed. It is doubtful if any other city has had a harder struggle in the matter of obtaining sewerage

facilities than has the City of Covina. The writer inspected the first proposed treatment plant site in 1917 as proposed in the original bond issue of 1914, accompanied by Mr. Floyd Dessery, then City Engineer. The site was located on Walnut Creek in the midst of walnut groves southwest of the city. The area surrounding the proposed site incorporated forming the City of West Covina specifically for the purpose of defeating the City of Covina in building a sewage treatment plant in their vicinity. The City of West Covina has never carried on normal municipal functions and remains today a community of scattered houses devoid of business, recreational, or residential centers.

In 1922 the city renewed its efforts to obtain sewerage facilities by employing the engineering firm of J. B. Lippincott and Company. A 100 acre site on the San Gabriel River north of Valley Boulevard was purchased for a sewer farm. A satisfactory outfall sewer alignment, however, was impossible to obtain because of right-of-way difficulties. The second attempt, therefore, met with defeat, although the city retained the land which it had purchased.

A third attempt was made in 1925 when Sanitation District No. 7 was formed comprising the greater portion of San Gabriel Valley and including the City of Covina. Covina, as a city, voted five to one in favor of the proposed district. Other cities in the district, however, refused to get behind a subsequent election for a bond issue and the district was dissolved in 1928.

In 1926 a fourth effort was made by Mr. E. P. Dewey, former City Engineer of South Pasadena, living at Covina, who advocated an activated sludge plant in the southwest corner of the city much along the line of the Pasadena plant which he had largely designed. His plan, however, failed to win sufficient support by the city trustees.

A complete sewer collection system was constructed in 1930 but could not be used until ten years later. In 1934, Mr. Crawford, City Engineer, endeavored to work out a highgrade sewage treatment plant in the southeast portion of the city which can be considered a fifth attempt by the city. At that time Mr. Alva J. Smith was employed to review the plans and later became City Engineer.

Mr. Smith recommended a treatment plant be constructed at the formerly selected site on the San Gabriel River. It was possible to utilize the site this time because the construction of the new Ramona-Garvey Boulevard to Pomona gave direct alignment for the proposed Covina outfall sewer for the greater portion of the distance, cutting the former length from eight miles to 5.6 miles. The firm of Black and Veatch submitted the plans. However, some very serious objections arose over this plan with nearly 4,000 complaints being registered with the State Department of Public Health. The latter held a hearing on March 27, 1935, in Los Angeles. The City of Covina proposed an activated sludge plant of 240,000 gallons per day at a cost of $36,000 designed for 4,000 people, with an operation cost of $25 per million gallons and with final disposal by spreading in gravel beds adjacent to the San Gabriel River. The principal protestants were the California Domestic Water Company and the Whittier Water Company supplying irrigation water to 7,500 acres and domestic water to 11,000 people, with a flow of 15 m.g.p.d. derived from wells adjacent to the property on which the City of Covina proposed its plant. While the nearest well was 750 feet distant, it was found that the sewage treatment plant would spread water into coarse sands, gravels in areas where the water table varied from 15-50 feet below the surface and where the material was sufficiently coarse and unconsolidated to cause quite extended travel of underground pollution. The treatment plant itself was located in one of the best water production areas in San Gabriel Valley. A second group of complaints came from people living in the vicinity of the treatment plant as well as subdividers immediately adjacent. While this site in 1922 had been quite isolated, it was now found to be in the middle of subdivision activity. There were 653 complaints from adjoining residents who would be fearful of odors from the proposed treatment plant. The majority of these complaints, however, were without foundation. The city was stopped, in spite of a valiant sixth fight, in its effort to build a sewage treatment plant and subsequently sold the land. In 1936-37-38 the city carried on an almost constant campaign with the County Supervisors, County Planning Commission, and the County Health Department in an effort to locate a treatment plant south and also northwest of the city because at the State Board of Health hearing it had been shown that ground water south of the city was more

than 200 feet below the surface and water courses existed where treatment plants might logically be located. None of these negotiations were successful so far as meeting objections of all interested agencies.

In 1939 Mr. Adolf H. Koebig Jr. was employed to work out a solution to this perplexing problem. After exhausting all other alternatives, he recommended construction of a highgrade treatment plant at the terminus of the previously installed sewer system and selected an adjacent orange grove for that purpose. The site was immediately annexed to the city. Its advantages were as follows: (1) by removing just those trees necessary for the treatment plant itself it was possible to secure adequate isolation as there were no adjacent streets or nearby houses; (2) the area in question was unsuitable for subdivision purposes; (3) the depth of ground water was over 200 feet with an impervious layer between the ground water table and the surface of the ground and, further, there were no nearby wells which might be in danger; (4) the soil at the proposed site was sandy and suitable for water spreading purposes; and (5) the sewage would be fresh.

Since the site is not located on any stream or storm channel, it was necessary to dispose of the effluent through cesspools at such times that it could not be used for irrigation purposes. The plan pre-supposed that the treatment plant would have to be odorless and the effluent clear enough to be disposed of in cesspools.

An injunction suit was filed by one of the neighbors and a lively court case ensued. Mr. Koebig presented the completed plans which showed that the proposed treatment plant was designed on a very liberal basis; that all odor destruction measures possible were included, such as ventilation and chemical treatment with ferrous iron and chlorine; that long periods of digestion would minimize sludge odors; and that filtration of the final clarified effluent either by irrigation on the orange grove or by disposal into cesspools would result in no overflow into adjoining property. The latter provision was necessary because there was no ditch, drainage course, or stream into which the Covina sewage after treatment could be discharged. The court held that the proposed plans were adequate in operating a treatment plant without an odor nuisance; that there would be no damage to adjacent wells from boron or sewage effluents disposed of underground; and that the underground wells were adequately designed to dispose of all excess waters which could not be beneficially used for irrigation of the orange grove, and denied the injunction.

The city constructed its plant and 26 years after voting its original bond issue it finally obtained sewerage facilities. The City of Covina is probably one of the few cities that has paid 26 years on sewer bonds without having any sewage facilities. It probably is also one of the few cities that has had seven different engineers submit reports and draw up seven different plans for sewerage works.

The writer has inspected the new treatment plant after its completion and has been most agreeably and favorably impressed by its operation. It truly is the clearest and most stable effluent of any permanent treatment plant in operation that the writer has ever seen. The present sewage flow is small and there is very little dilution of laundry wastes in the final sewage as it reaches the plant, but no particular difficulty has been experienced in its treatment. As additional sewer connections are made and the sewage flow is increased the sewage will become more normal and easier to treat. The plant, so far as I can see, has met all expectations of the designer, complies fully with the points on which the injunction suit was denied, and is producing a marvelous effluent. This plant is one of the few to be constructed and placed into operation without an avalanche of "bugs" which usually haunts all new plants. Operation costs are not yet available, but they should be within reason, and when operating at the designed capacity may compare favorably with the combined sewage treatment and water purification costs of similar separate processes elsewhere.

I have been told that people in the vicinity who once protested against the proposed treatment plant are thoroughly satisfied that their fears were without foundation and that there is no desire on their part to further embarrass the city in the matter of their sewage disposal problem.

THE MAINTENANCE OF SANITARY SEWERS IN SAN DIEGO, CALIFORNIA

By **BYRL D. PHELPS,** ***Assistant City Engineer***
City of San Diego, California

The City of San Diego, California is situated along the Pacific Ocean and Bay of San Diego. The land adjacent is traversed by canyons and sloping drainage areas. In many cases the sanitary sewage systems were put in as units to serve each particular section of the City as building of structures demanded sewers. These small trunk lines emptying into septic tanks and creek beds were later joined together with trunk sewers and discharged into the Pacific Ocean through outfalls and into the Bay of San Diego through outfalls. In April 1940 there were 525 miles of sanitary sewers serving a population of 180,000 to 200,000 persons scattered over an area of 21 miles in length from Northerly City limits to the Southerly boundary line of the City of San Diego.

The City of San Diego has provided a Division of Sanitary Sewers consisting of the following personnel to maintain this system only:

1 Acting Superintendent
1 District Foreman
2 Crew Foremen
3 Acting Crew Foremen
4 Plumbers
2 Sewage Pump Mechanics
30 Laborers

The City Engineer's Office cooperates with the above personnel on special problems.

The Division of Sewers has the maintenance of all the sewers in the City of San Diego. The Construction of sewer laterals in unpaved alleys and streets and the connection of the sewers from the property line to the trunk sewers also comes under this Department. In some cases short extensions of sewers are made by this Department. The charges for this work are $15 for sewer laterals in dirt alleys, $20 for paved alleys, $30 for sewer laterals in dirt streets, and $50 for paved streets.

The maintenance of the sanitary sewage system begins at the outfalls and the following problems have arisen. First, the anchorage of the outfalls. This has been done with steel railroad rails, but serious disintegration of the iron in salt water and sewage has caused portions of the outfall to break, then sand enters the portion left and problem No. 1 enters the book on how to remove the sand. The use of fire hose and water jets has proved successful in many cases, but in several instances the sand was packed so tight that this method was not successful. Sewer rods with special cutting blades have been used with good results, but in one case at Mission Beach the rods broke in the pipe and a new problem was added—that of removing the broken rods.

One solution was found to construct the smaller outfalls of genuine wrought iron pipe and install cleanout holes along the line with bolted plate covers. These may be utilized for cleaning purposes. At the end of the outfall two elbows were turned up. The entire outfall was wrapped in

canvas strips and coated with a Bituminous coating then floated in place and anchored in the sand with chains. This line has some flexibiilty and has not given trouble from sanding up.

The settling tanks along the Ocean are a constant maintenance problem. The emptying of sludge at the proper time to prevent odors has caused the ever ready excuse to let it go and then the tanks become overloaded with sludge, pipes cake up and it is impossible to empty the tanks after the valves are opened. It then requires the use of sludge pumps or hose on a jet to break up the solids. Vent pipes on the tanks are a constant source of trouble. Either the public is plugging up the pipes with sticks and stones or breaking off the goose neck vents and plugging them up causing gas to form in the tanks. In some instances considerable odor has been noticed at the vent pipes, especially if the Ocean surges into the outfall forcing air into the tank. Vents have been run up beside telephone poles and also disguised as lamp standards to try and detract the attention of the public—but a nice down draft and hydrogen sulphide is not so easy to hide.

The next problem is to get rid of the gasses if possible. This was solved by installing a small plant to make ferric chloride at the pumping plant ahead of the settling tank and outfall.

Pumping plants are a nice useful part of a sewage system until something goes wrong. Poor ventilation will cause condensation on the ceiling and little drops of water on switches, wire terminals and motors—and finally trouble. Ventilation holes in the pump house located in the exact manner as needed turn out to be inlets for rain in a storm, and the result is a flooded motor at the time most needed.

The idea of a pump house vent in a residential district is not to be tolerated, but a vent disguised as a beautiful flag pole or bench is an asset to any community.

Pump house floats to operate the pumps are always easy to design and look well and neatly balanced in a catalogue, but after a few weeks in a nice strong sewage some problems are sure to occur. The metal is eaten up and so a new wood float is tried out; it is wonderful until waterlogged with sewage and then trouble begins; so the friendly glass jug with a cork is used with equally as small a chance of success. Now newer methods with electrodes are developing electrical gymnastic tricks to fool the operator.

Sewage pumps that pass all solids that are not held on bar screens are now constructed and operate until a small piece of wood 1⅞″ wide and 6″ long passes a 2″ bar screen opening just so it can crowd into the pump and stay wedged in place to defy all gauge readings, the search for tuberculation in pipes, and the undersize outlet and inlet pipes, back washes and every other known test until you decide a new runner is necessary and the little piece of wood is finally pulled out of a hole in the runner to end all trouble for the day.

Room around all removable parts or pipe flanges, access to all grease cups, and oil lines are the safest means of cutting down maintenance costs in pump houses. A check chart of oil and grease service points will tend to have the operation done systematically.

The maintenance of sewers in streets and alleys is the duty of the Division of Sewers. Most of the trouble comes from clogged pipes. The source of the trouble is always hunted and the following problems have arisen, one of

which is proper joints. The flexible mastic joint is easy to pour and allows a settlement or movement in a pipe but it also allows small roots to start through the compound and in many instances if in the neighborhood of certain trees the entire pipe has been stopped with roots. The small roots grow and crack the pipe allowing larger roots to enter. The use of solid joint materials generally insures a rigid joint and few roots. If the trench has been cut through hard ground the roots follow the back fill and grow under the pipe and gradually raise and break a pipe and then enters the pipe to clog it up.

The attempt to stop roots from entering the pipe has been made by using copper wire in the cement joints. Also the use of cast iron pipe with lead joints in places where the pipe passes under trees or shrubs. Care with the jointing of cast iron and other pipes must be taken. Joints made with moist cement and caulked in place have proved satisfactory on small sewers.

The removal of roots is a problem that takes from one hour to days. In most cases a cutting screw used with flexible rods can accomplish the work. Blue vitrol poured into the roots will kill the roots in some cases. In one instance a pile of roots in a six inch pipe was 6″ in diameter and 30′ long and looked like a sea serpent when removed.

Sewer rods are operated in some instances by hand, but new machines capable of turning long lengths of rods are now being used with wonderful success.

The use of a beach ball has proved of considerable advantage in cleaning sewers containing sand. A double scraper pulled between manholes will clean out small rocks and sand. A chain fastened to a windlassor truck may be dragged through the pipe to clean out stones.

All holes in manholes should be plugged tight. A root many feet long and ¾″ in diameter went through a hole left for a manhole step. Manholes made of concrete should be given a water proof coating outside and inside.

Sewer maintenance could be helped considerably if complete records were kept of all work put in and any changes from the original plans should be shown on the records. This will require close cooperation between construction crews, maintenance crews, and the Engineering Department.

The public expects the maintenance crew to immediately eliminate the trouble so as not to hold up some baby's bath or the head of the family's shower. No matter how efficient the maintenance crew may be if the sewage runs through the front room onto the rugs, the property owner will have something to say and many times damage suits can be averted by proper maintenance of the sewage system.

Let us give one cheer and a medal to the man every bit as important as the fireman, policeman or any other public servant—the man who maintains our sewage system and who is seldom seen and never heard from.

Discussion:

The Maintenance of Sanitary Sewers in San Diego, Calif.

By Carl M. Hoskinson, Chief Engineer, Division of Water and Sewers, Sacramento, Calif.

The paper by Mr. Phelps on "Maintenance of Sanitary Sewers in San Diego" calls our attention to many interesting although not always pleasant problems which confront the Foremen and Maintenance Crews operating Sewer Systems.

The City of Sacramento operates a combined Sewage Disposal System which

we believe includes all of the problems of a sanitary system and possibly a few more as solids passing through sewers may be larger and, therefore, may create more problems for Service Crews. On the other hand large sewers may be much more easily inspected and cleaned by crews working directly in the sewers.

Th area of the City of Sacramento is approximately 14 square miles. The City operates approximately 250 miles of sewers and serves a population of approximately 121,000.

The sewer design and grading comes directly under the City Engineer and the operation of sewers and disposal of sewage is handled by the Division of Water and Sewers.

The maintenance crew for the sewer system comprises one foreman and eight laborers. The normal crew for dry weather pumping consists of three pump operators, two helpers, one machinist, and one machinist helper.

The supervisory personnel of the Division of Water and Sewers comprises superintendent, chief engineer, assistant engineer, and one general foreman, who, in th above order, control the operation of the dspartment.

Sewers are usually installed by contractor under the bond plan, and the Division of Water and Sewers makes service connections as necessary.

Sewers of the smaller sizes are of terra cotta pipe with cement joints. Larger sewers are of concrete pipe and of recent years have been of the precast type.

We have experienced the same troubles in maintenance of sewers caused by entrance of tree roots mentioned by Mr. Phelps and have found that flexible sewer rods have been the best means of removing these obstructions which occur for the most part on rights of way rather than on streets and alleys. During stormy weather the cleaning of storm drains is taken care of by the division of the city into eight districts of which two districts are taken care of by the Division of Water and Sewers, three districts by the Street Department, two districts by the Waste Removal Department, and one district by the Park Department. It is the duty of these crews to see that gutter drains are kept open during stormy weather.

The charge for sewer connections to sewer is $3.25. The charge is $2.00 per lineal foot for cutting and replacing povement and $1.00 per lineal foot in unpaved alleys and streets.

Surely the surest way to make a sanitary department unpopular is to allow odors to arise in sewers, manholes, vent pipes or pumping stations. It is surprising what odors arising from various sources will be attributed by the irate inhaler thereof to the sewer systems and the one in charge of sewage disposal can expect to be called any time at any place to suppress sewer smells.

In one case we were called late one evening and found the smell was actually drifting across the river from a fire burning on the surface.

Our present disposal is accomplished by pumping into the stream flow of the river and it was necessary three years ago to extend the effluent pipe 270 feet into the stream to prevent deposits of sludge on sand bars which certainly created a nuisance. The disposal of the flow in the current has overcome this difficulty.

The prevention of corrosion of iron and steel in pumping plants has always been a problem where sewer gases are present. We have endeavored to solve this problem by use of coal tar enamels. The use of paints containing lead in sewage plants where sewer gases are present is not advisable as the lead is attacked in a short time by sewer gases.

Copper tubing and copper floats have been found quite successful in connecting up gauges for indication of sewer levels. Screen fine enough for protection of pumps is desirable but should not be carried to the point where excessive screenings must be otherwise disposed of if the solids passing through the effluent are not limited by other considerations.

The size and shape of objects which may be caught on sewer screens seem to be only limited by the size of manholes on the system as we have known of construction ladders 8 feet long, whole cases of canned fruit, cats, dogs, and many similar waste products caught on the waste screens. One case causing the greatest furor was a set of false teeth which by chance was mentioned to one of the new reporters who made a humorous story of the incident, but it was taken seriously by no less than a dozen residents who laid claim to the teeth, which they claimed to have lost in a wide variety of ways. One man claimed the teeth belonged to

him but that they had become slightly misshapen by passage through their tortuous course to the pumping plant.

In another instance paper money was found on the screen and claims for same which were never substantiated were made by many people. At another time a very valuable diamond ring was lost in the sewer and by quick wit of the foreman it was caught the next morning just below where the house service entered the main sewer. As previously stated, there seems to be no limit except size of inlets to what will be dumped into the sewers and the sewer maintenance crew of any city may never fear being out of a job.

OPERATORS' SYMPOSIUM

GADGETS

By A. E. FISCUS

Mr. President, Distinguished Guests, Fellow Sewagicians and Friends: I was requested to talk, on some problem that has confronted me as an Operator of a Sewage Treatment Plant, and the method used to remedy or eliminate the trouble. Now you all know a Treatment Plant Operator has no troubles, only slight worries.

However, if a man is gadget minded and a diplomat, he may qualify as an Operator. There are two main reasons, and many lesser ones why a diplomat is required. First, at our plant on Terminal Island we are blessed by having several Fish Meal Plants close by. And when they (over cook) as they explain it (in plain every day language BURN) the meal, there is considerable odor thrown off, and it doesn't smell like violets. When the aforementioned happens, we are sure to have some native of the Island, even though he may work in one of the canneries, complain to us. THEN it takes a Diplomat to convince them we are not the offenders. The second reason an Operator should be diplomat is, (latest definition, anyone who can convince his wife she does not want a fur coat because it would make her look too fat and still be on speaking terms with her) that on the salary paid operators, diplomacy is compulsory.

Now any plant is only an assemblage of gadgets, placed in some sequence so as to perform collectively some specific task or operation. Since a Treatment Plant falls in this category, it is obvious that an Operator should be gadget minded.

A few of the gadgets at our plant, which we have made and installed on the job are: sweep-timing, odor control, pump primer or degasser, level indicators for the decanters, gas control, antielectrolysis equipment, etc.

Taking these as named and going as much into detail as allotted time and your patience will allow, I'll explain first sweep-timing. Our plant was designed with the idea of pumping intermittently over the 16 hour operation period. To accomplish this an electric time clock was installed, on which several schedules could be used. We found after trials and pumping five minutes on and off, ten minutes seemed to be best. However, we were still troubled by irregular quantities of sludge. Upon analysis of this condition, I came to the conclusion that the pumps and the sweep in the clarifier were not synchronized. Perhaps I should say our clarifier is an 80 ft. Dorr Sifeed,

with four arms with plows to force settled solids toward center and sludge pocket. And since this mechanism did not take an even number of minutes for one revolution, part of the time the pump would be pumping as the sweeps were pushing heavy sludge to sludge pocket and again after sweep had passed and only thin sludge in pocket. I overcame this by installing a switch timed off the sweep and set to pump only as sweeps approached the pocket and stay off until next one approached. Now, often we do not have to change speed of pump all day, and yet our sludge has practically a constant moisture content. I might add the moisture content of our raw sludge as we pump it is between 92% and 94% average.

Odor control is another of the operator's headaches. Odor can't always be laid to Fish Meal Plants, you know. We found most of our odor came from our launder around the clarifier and Parshall Flume, due to aeration. We overcame most of the odor by decking over these and installing burners, fired by gas of which we have an abundance. I am not sure whether the odor is burned or merely dissipated by dilution. Much more research is needed on this subject.

Pumping either septic sludge or digested sludge is a problem in any language (even profane). We are equipped with two Chicago Screwpeller and one Barn's Dorrco Sludge pumps. Of course, the plunger pump is out for many reasons: noise, slowness, danger of blowing gaskets, etc; but with the centrifugal pumps we had trouble with gas binding. Another gadget was called for. We take the gas out before it gets into the pumps, and believe it or not, we have pumped gaseous material when the intake was registering from 20 in. to 24 in. mercury vacuum.

No doubt many have had the experience of trying to keep floats in wet wells or tanks of sewage. Enough said! We use air and gauges calibrated in feet of water. Some plants use something of this nature but with diaphragms and if it is subjected to heat changes or springs a leak—too bad. Our arrangement can be set up with gauges at great distances from tanks and also either above or below tanks as situation may require.

I have visited several plants where their gas disposal was not a problem. Well, they were lucky. Our plant was equipped with 4 inch gas line, a 3000 cu. ft. holder floating in the line, plenty of safety devices, but a meter that was designed to handle 3500 cu. ft. per hour with 5 inches water back pressure. I have been able a few times to force 5000 cu. ft. through per hour before the water seal around the gas dome blew. Then, we had to by-pass meter and look up in the sky and guess on how much gas we were making. This guessing was the better part as the worst was the disposing of the gas or the burning of it. Our water heater for Digester uses around 800 cu. ft. per hour, the incinerator perhaps 1500 cu. ft., escapement burner perhaps 2000 to 2500 cu. ft. per hour. The question was what to do with the rest. We have overcome this by installing an auxiliary 3 inch line from gas dome to another auxiliary burner, with a valve controlled by the gas holder. Since this is in operation, we have been able to hold pressure in gas system within 0.6 inch water.

About two years ago the mechanism within our Digester broke down and had to be renewed. We found the metal eaten as deep as 1/8 inch spots. We knew this could not be oxidation, as our digestion is anaerobic, hence no oxygen present. On further investigation we found a potential of 1.6 volts

D. C. current. After an exhaustive search, which included disconnecting all outside connections except the telephone, we found our currents to be generated in the Digester itself. We installed a test board and have been able to make all metal cathodic and installed a sacrificial plate in each manhole which is the only anodic metal in digester. This seems to be successful and will be reported at some future date in full.

I hope I have not been too much of a bore in this report and am going to close with the thought in mind that if any one has any questions on these gadgets I will be glad to answer them. If any subject touched in this paper is of interest to a large enough group I will be very glad to report at a later meeting in full.

I thank you.

SLUDGE BEDS

By CARL F. TENNANT

There is no doubt that sludge beds afford the cheapest and possibly the best method of dewatering digested sludge in this locality.

The most expensive type of bed, of course, is the underdrained sand bed with glass covering. This type of bed is hardly justified in the dry climate of the Southwest except in special cases where residential development may press in very close to the treatment plant and when the prevailing wind is in the direction of a residential district.

The standard underdrained sand bed without covering is the most common. The principal difficulties are the loss of sand with the removal of the sludge cake, flies and odor.

If odors arise they may be best controlled by having the sludge well digested but even this may not eliminate all odors from the sludge beds. The beds and the plant in general should be located so that the prevailing wind will not spread flies and odor toward any residential section. When dry, digested sludge is wet with rain water early in the Fall when temperatures are still high a very offensive odor condition may prevail for a few days. Two avenues of relief present themselves in this situation. One is to provide sufficient storage space so that sludge may be retained in deep lagoons and dumped at suitable seasons, preferably from late Spring after fly season is past and the weather is good for drying to midsummer when all sludge will be dry and removed before early rains come. Sludge may also be spread without objection after the weather has become cold. Sludge can be stored in deep lagoons without difficulty arising from odor or flies. The other method is that of pumping digested sludge on top of sludge that may have become offensive due to early rains and warm weather. This method retards the drying time; more spreading ground must be provided if this practice is to be followed.

The cheapest type of sludge bed is the shallow lagoon and it is upon this type of bed that about sixty per cent of the sludge of the Los Angeles County Sanitation Districts is dried. These beds are laid to a grade of two inches per 100 feet and can be filled to a depth of about two feet. Sludge of about ninety-five per cent moisture will move very slowly on this slope, but the

water that separates after pumping will leave the sludge by way of small river systems on the surface and will run on ahead and can be decanted from the bed at the lower end. Beds 1200 feet long working in this way have been successfully operated. The floor of the beds are kept hard for better operation of the removal trucks and the loader which operates in the bed when the sludge is dry. The sludge cracks loose from the ground and can easily be loaded without scooping up the dirt.

Two methods of loading are used. One is a standard scoop type loader. The loader and the dump trucks work in the lagoon which must be wide enough to permit easy turning of this equipment. The other method used by the sludge contractor is that of winrowing the sludge by means of a tractor and scraper ahead of a truck crane which loads the dump trucks from the winrows. Two methods are used to turn the sludge to speed up the drying process. One method is to use a horse and small stirring plow; if the sludge is too deep for this a caterpillar tractor is driven through the lagoon to break up the crust and bring new moisture to the surface. Either of these methods greatly shortens the drying time of the sludge.

Two and three-tenths acres of underdrained sand beds are in operation at the Districts' treatment plant upon which some 663 tons of sludge per acre per year are dried. Seven and two-tenths acres of shallow lagoons produce some 342 tons of sludge per acre per year.

With the combined primary and activated sludge process it was necessary to provide seven-tenths of an acre per million gallons of sewage treated; whereas, at present with primary sedimentation only about four-tenths of an acre per million gallons of sewage is needed.

The lower cost, the ease of removing the sludge cake, more convenient operation, resanding, etc., all strongly recommend shallow lagoons against sand beds for the drying of digested sludge if the lagoons are properly laid out and located.

EXPERIENCE IN REMODELING MECHANICAL AERATORS IN LAGUNA BEACH PLANT

By R. D. WOODWARD

In our activated sludge plant at Laguna Beach, we have had the opportunity of doing some interesting work upon aerators of the mechanical type. The aerators as installed originally consisted essentially of an electric motor driving an axial flow screw propeller centrifugal pump through a vari-speed drive. The motor is rated at 5 H.P. and the pump at 1800 GPM against a 4.3 ft. head. The pump forced the liquor from the aeration tanks through a jet, surrounded by an air chamber open to the atmosphere, and into a header placed the length of and along one side of the aeration tank. Holes were placed along this header so as to allow the pump discharge to be distributed throughout the tank. The liquor in passing through the jet creates a vacuum in the air chamber and thereby, air is drawn into and aerates the liquor.

After operating these aerators for a period of two years we found that, even though we overloaded the motors and operated the pumps at the highest

speed available, it was still necessary to use four aerators each installed in a 50,000 gal. tank in order to get an effluent that was passable but not of the best during our summer flow of 300,000 G.P.D. Operating under these conditions gave us a total of 29.4 H.P. input to the four motors and, being unquestionably too high, it was decided to do something about it. Inasmuch as the pumps are submerged in the aeration tanks it was decided to measure the amount of air drawn into the air chamber in order to get a quick check of the progress made and to make said measurements an orifice meter is used.

Working in close cooperation with the manufacturer, great progress has been made and we feel that in a very short time we will have a very efficient aerator. At the first revision of the aerators it was decided that, if it was necessary to drive the pumps at maximum speed, it was hardly necessary to have a vari-speed drive, therefore, the pump was directly connected to the motor and at the same time the friction loss through the pump was reduced by enlarging the suction inlet, discharge outlet and header. At the same time it was decided to divide the one header into three separate headers and thereby give a more certain distribution along the tank. After this first change we found that each aerator put 21 cu. ft. of air per minute into the tank as compared to 12 cu. ft. of air per minute with the original installation. With this additional amount of air we found that we could use less tanks then formerly for the same quantity of flow and cut our horsepower input to 17.4 H.P. during the summer and 11.0 H.P. during the winter, thereby cutting our power bill substantially. However, after two or three months running we found that our air had dropped off to about 18 cu. ft. per minute, therefore, inasmuch as we had not reached the volume of air we had really hoped for in the first revision, it was decided to make another attempt. This second attempt took the form of building up the impellor and machining both the impellor and pump bowl to fine accuracy and minimum clearance and when this was done we found that the aerator drew 30 cu. ft. of air per minute which is about as high as we expect to get with the present pump capacity. However again, after about two months operation, the volume dropped to 24 cu. ft. of air per minute and being dissatisfied with its failure to continue pumping the higher volume of air, it was torn down and is now being remodeled again. When the pump was taken apart, excessive wear was found in the impellor and in one bearing which apparently caused the air volume to drop off, therefore, an additional bearing is now being installed directly above the impellor together with a flexible coupling to the motor and it is felt that with this change we will have a sturdy and dependable aerator capable of giving us all the air we shall ever need.

In the foregoing description I have eliminated the many minor things we have tried and discarded but I believe I have covered the major points of interest. I might say further, however, that though our plant is small with a designed capacity of less than 1,000,000 G.P.D. we are faced with a number of problems due to the great relative fluctuation in flow because of the large influx of population during the summer and over week ends which is common to all beach cities. I feel, though, that our main problem, lack of air, is nearly solved if progress in our aerator operation continues as indicated and that our mechanical aerator installation will be entirely satisfactory for a plant of our capacity.

CAUSE, EFFECT AND REMOVAL OF SCUM FORMATION IN THE DIGESTER AT THE PALO ALTO SEWAGE TREATMENT PLANT

By HAROLD L. MAY

The operation of the digester has been more or less of a problem from the time the plant was started. It is believed that the principal cause for these difficulties is the excessive scum formation due to the cannery waste.

Sewage treatment at Palo Alto consists of combined bar screen and grit chamber mechanically cleaned, sedimentation and separate sludge digestion.

The digester is of the circular patented Hewitt type with a spherical top and conical bottom. It is 50′ in diameter, 37′ deep at the center and 25′ deep at the sides, with a capacity of 52,000 cu. ft., designed on a basis of 1.5 cu. ft. per capita.

Raw sludge enters the digester thru four inlets in the top. The openings form the corners of a 16′ square with the center of the square at the center of the digester. Each inlet is controlled by a valve, so that the sludge may enter thru any one or any combination of valves.

There are four overflow pipes, at levels of 4, 8, 12, 16 feet from the top. The overflow piping is so arranged that the liquor may be returned to the raw sewage, or it may be recirculated by means of the sludge pump thru the raw sludge inlets at the top of the digester, or it may, by recent changes made, be pumped by the sludge pump to the sludge drying beds.

Reading thru the logs and records of the plant, I found that the scum formation had a wonderful start. The plant was first put into operation in July, 1934, with the cannery beginning its seasonal activity about the same time. The plant received all the waste without benefit of the screen that has since been installed at the cannery. Incidentally, this screen is about as effective in retainingg tomato skins as a sieve is in holding water. The openings are about ½″ square. It does remove most of the large fruit, that is when the screen hasn't broken down, which frequently is the case. At any rate, we still receive the tomato skins, the main element of the scum mat.

Considerable foaming occurred during the first few months of operation. Foaming, of course, is not an unusual occurrence in starting an unseeded, unheated digestion tank, but I believe, that due to the character of the waste treated, an unusual amount of foaming occurred.

Shortly after the canning season was over the foaming ceased. By April 1935, the digester heating system had been started and the pH was up to 7.0.

The scum with the tomato skins had formed a tough fibrous mat, which by the end of the 1935 canning season had built a mat four feet in depth, clogging the first overflow level. By the end of the 1936 canning season the 8′ level began to clog. Frequent drawings of digested sludge helped to jar some of this mat down and prevented the total clogging of this level. In October 1937, the middle of the tomato canning season, the scum mat reached the 8′ level and clogged it completely.

Recirculation of the sludge was tried at this time to see what effect it would have. It caused the digester to foam and seemed to aggravate the

condition. In April and May 1938, after the spinach pack the 12′ level began to show signs of the mat reaching this level. Large slugs of tomato skins and heavy sludge would flow out with the liquor. The same conditions that preceded the clogging of the other levels.

It seems, therefore, that the cannery wastes are the cause of the excessive scum formation, principally the tomato skins. The main effect has been the decrease in digestion capacity. However, at all times, the sludge drawn off has been well digested.

It had been difficult to keep the solids content of the overflow liquor low enough to prevent the upsetting of the sedimentation tank. It was therefore decided in June 1938, to divert the overflow to a nearby field. The clarifier was very grateful to be relieved of that burden.

In an attempt to remove some of the scum a four dollar hand bilge pump was purchased. Mr. Maclachland, our city water works engineer, had his men build us a means of operating the pump mechanically out of a motor from an old coffee grinder and a few odds and ends around the water works. The pump was placed down the 8′ level overflow pipe and operation started.

Progress was slow, but we were able to remove a large quantity of scum and tomato skins. Eventually we were able to get the overflow to run free. The pump was then moved to the 4′ overflow pipe. The scum mat was so thick and tough at this level that the pump wouldn't work.

The overflow liquor was beginning to be fairly decent when along came the 1939 canning season. From the amount of tomato skins received at the plant, it seemed like every tomato grown in the State was processed at our cannery. It was no time until the 8′ level was clogged. The pump couldn't keep up with the load and finally this level became so clogged that the pump wouldn't work. The 12′ level also began showing signs of clogging.

Of course, one way of getting rid of this scum is to empty the digester and clean it out. But, as perhaps many of you know, this isn't as simple as it sounds, nor is it a pleasant task, besides it is a dangerous operation.

About this time the nearby field had become full of tomato skins. While there wasn't any nuisance as to odors it was beginning to be unsightly. Therefore it was decided to run the overflow into the sludge beds, where it could be dried and removed easily.

To do this with the least expense, a 'T' in the raw sludge line on top of the digester was changed to a cross and a valve put on the open end of the cross. A pipe line, from the valve to the sludge beds, was constructed out of second hand irrigation pipe.

The operation of this arrangement sounds like something Rube Goldberg would think up, however it has been very effective. It consists in pumping the raw sludge in to the digester until it has raised the level in the overflow box about 2 feet. This causes the scum mat to be pushed up against the spherical top. The overflow is passed thru the recirculation pipe to the sludge pump, pumped thru the raw sludge line into the digester for a few minutes to allow the raw sludge in the line to be flushed out, then the valve at the cross is opened and the inlets to the digester closed, allowing the overflow to flow down the side of the digester thru the irrigation pipe into the sludge beds.

Now this raising and lowering of the level of the sludge in the digester had the effect of breaking up the scum mat. Within a week a tremendous amount of scum and tomato skins had been removed from the 12′ level and a fairly clear liquor began to come out. This liquor was recirculated in an attempt to soften up the scum mat and the bilge pump was again placed in the 8′ overflow pipe. Within two weeks this level had cleared up with another large volume of skins and scum removed.

Just as we were beginning to have some success with this operation, the digester heating system developed a leak in the piping somewhere inside the digester. This brings the records up to the end of February 1940.

Rather than undertake the repair of the digester at this time, Mr. Byxbee, our city engineer, suggested that we operate the digester unheated for awhile and see what develops.

We got along very nicely for about two weeks. The solids content and volatile matter from the 8′ level was lower than it had been four years.

Then the cannery started the spinach pack. In previous years the season had been short and the pack light. Very little, if any, effect was noticed on the digester during these years. This year they worked 24 hours a day for four weeks.

Down went the scum mat past the 8′ level and into the 12′. However, a few days after the spinach season was over the liquor from the 12′ level began to clear up. To date, April 18, 1940, the 12′ has cleared up and the 8′ is beginning to clear itself, and another large quantity of scum and skins have been removed.

Since the deadline for this report is April 20, I'll have to report future results at a later date. We hope, if we ever get to have a long enough breathing spell between canning seasons, to clear the 4′ level.

I want to thank you, gentlemen, for listening to our troubles.

SLUDGE PUMP CONTROL

By VERNER C. JOHNSON, *Covina, Calif.*

In observing the pumping of sludge from the primary clarifier which is of the circular type with the conventional Dorr equipment, it was noticed that the timeclock operated pump would come on some times just after the sludge scraper had passed the recessed hopper in the bottom of the tank and at these times very thin sludge was added to the primary digester.

The thought occurred that if the pump switch was operated by the clarifier mechanism it would be possible to pump only at the time that the plow was approaching the hopper and be off the rest of the time, thereby removing a much thicker sludge.

The result was the working out of a mechanical device to operate a mercuroid type switch by the movement of the clarifier turntable. The first model was constructed of wood and when installed proved very satisfactory and was in use for some time until another unit was made of metal. The new unit has an additional switch to control the Turbo Mixer on the primary digester. The Turbo Mixer is shut off a few seconds before the sludge pump-

ing period which is once every hour, and turned on again when the primary over flow has stopped. The pumping period is 35 to 40 seconds. We have had no trouble with the digesters and the pH stays at 6.8 to 7.0. The raw sludge averages 95% moisture. It has been possible to pump 90 to 92% moisture but then we have some floating sludge in the clarifier so we adjust for about 95% which seems to be about right.

The sludge pump is an American Well Works centrifugal type pump with a Sterling Vari-Drive motor.

The mechanical switching unit consists of a metal box 9″ x 9″ x 16″ mounted between the I beams of the clarifier walk way with a trap door cut in the floor directly over it.

The turntable carries an arc of a circle of a flat band about 4″ wide with 2 rows of holes spaced about 3″ on center, and of a radius sufficient to pass under the center of the box housing the mechanism. Into one hole in the outer row of holes is placed a start peg and in one of the holes of the inner row is placed a stop peg. The start peg, as it passes under the box, engages one of four spokes extending from a hub which is mounted on a vertical shaft that extends up thru the box. Each time the peg comes around it causes the shaft to turn one fourth of a turn. As the clarifier makes one revolution in approximately fifteen minutes it will require one hour to turn the shaft one revolution. Inside of the box and mounted on the shaft is a metal disk which carries a cam. A mercuroid switch is mounted on a lever so that it swings up when the cam passes under it. As the start pin leaves the spoke it will leave the cam roller on the cam and the pump will continue to run. The stop peg in the other row of holes engages a like spoked hub and shaft which carries an arm that engages a peg in the under side of the disk on the other shaft which pushes it just far enough to move the cam from under the switch lever, thereby shutting off the pump. The distance between the pegs will determine the pumping period. The off peg is located so that the pump will stop just as the sludge scraper passes over the hopper. If a longer period is desired the start peg is moved forward to have the pump on sooner.

Two sets of pegs may be used to pump when the other scraper comes up to the hopper.

The turbo mixer switch is operated by another cam of smaller radius mounted on the same disk as the pump switch. The length of this cam is cut to suit the mixing period desired.

With the combination of a variable pumping period, a variable pumping time, and a variable pumping rate it is possible to pump any desired thickness of sludge within reasonable limits. The danger of upsetting digestion is lessened by pumping small quantities at frequent intervals.

The first month that we used this unit we averaged 92.4% moisture but had some small amount of floating sludge on the primary clarifier. As our plant is located within the city limits and only one block from the best residential district we could not take any chance of having an odor develop so we set the unit to pump 95% moisture.

EXPERIMENTS CONDUCTED AT THE LOS ANGELES CITY PILOT PLANT

By H. G. SMITH* and E. G. STUDLEY**

In connection with the study for the betterment of the Los Angeles Sewerage system, there has been more or less of a tacit understanding by all parties concerned that one of the essential corrections regardless of differences of opinion relative to other improvements, was the junking of the existing screening installation at Hyperion and the construction, at that location, of a modern type of sewage treatment plant in order to eliminate the pollution of the bathing beaches on either side for several miles and also the atmosphere in the general vicinity.

It has been conceded, at least by the technically informed, that with Santa Monica Bay as a point of final disposal with its currents continuously bringing in millions of tons of clear salt water from the channel and thereby presenting an extremely large dilution and oxidation factor, any type of so-called complete treatment would be decidedly uneconomical and uncalled for.

Studies relative to design for a new plant were commenced by the Sewer Design Division of the Bureau of Engineering as early as 1934 at which time plain sedimentation and separate digestion only, was considered, the sludge to be dewatered on vacuum filters and the process continued in tubular dryers and incinerators with moving grates. Center feed clarifiers were just coming on the market and several types of flash dryers were being experimented with. The use of digester gas as an engine fuel was in its extreme infancy and flocculation without chemicals, or mechanical flocculation, as we know it today, was not a proven factor in the treatment of sewage. Elutriation was still to make its general appearance and numberless gadgets and methods of control now common in many new plants had not been heard of.

Therefore, even so far as our general design, to say nothing of detail, at that time was concerned it was really a far cry from that of the plant now outlined and proposed.

With the expectation from year to year that either through pressure or conscience the City would decide to clean up its beaches, the Sewer Division has designed and redesigned, keeping abreast, at least on paper, with the new developments in treatment as experiments and installations were made from time to time by engineers fortunate enough to see their dreams come true. In fact the general flow chart of this plant is now known by its edition number rather than plan number, four editions having been prepared to date.

In 1927, some quite extensive studies and experiments were made by Messrs. Knowlton and Parkes relative to the recovery of the grease content from Hyperion Sewage. While the experiments resulted in the development of a type of special grease recovery equipment which it is intended to adopt in the proposed new plant, due to lack of available funds no further experimental work was conducted until the summer of 1938 when the pilot plant, now under discussion, was placed in operation.

The purpose of this plant has been to simulate on a model scale of practi-

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cal dimensions, operations that might be conducted in a full size plant and thereby test different methods of clarification, digestion, elutriation and dehydration of sludge in several types of equipment, with various chemicals and without, and to study the reactions of this particular sewage through one year in order to acquire further data relative to the rational design of a flocculation-sedimentation-stage-digestion type of treatment plant.

Routine tests were conducted (in duplicate) daily in the plant laboratory while samples requiring special analysis and more complicated chemical apparatus were sent to the City's Bureau of Standards.

This experimental plant as outlined in Figure 1 consisted of 2 clarifiers with a capacity of 200 gallons each and a third clarifier with a capacity of 900 gallons. The two smaller clarifiers were used for experimental clarification and the third clarifier was installed only to produce sludge for the experimental digesters.

A flocculator with a capacity of 50 gals. and equipped with three sets of three paddles each, revolving at a speed of 11 rpm was constructed adjacent to the upper end of one of the smaller clarifiers.

Thus with a flow of 2400 gals. per day to each of the smaller clarifiers 30 min. flocculation was obtained with 2 hr. retention in the clarifiers. This flow was obtained from the Hyperion Screening Plant effluent by means of air lifts. This flow was first conducted thru a trash rack where the larger materials that passed around the screens were taken out so as not to obstruct the smaller openings throughout the system and then taken through a constant head box with controlled orifices for each clarifier so that a uniform rate of flow was always obtained.

The flow from the flocculator to the clarifier was under a separating baffle, there being no inlet weir in the latter tank. The clarifier effluent passed over a weir the full width of the tank.

Once or twice each day the clarifiers were squeegeed by hand, the sludge drawn off through separate cocks and pumped to sludge storage barrels for thickening by decantation.

When chemicals were used, they fed with the influent to the bottom of a flash mixer with 75 sec. retention from which the influent overflowed to the flocculator.

A second flocculator was installed ahead of the other small clarifier during the two stage clarifier experiments. For one hour retention, false sides and an end were placed in one of the clarifiers so as not to reduce the retention period in the flocculator.

In order to determine the effectiveness of clarification under all conditions, samples were taken from 8 A.M. to 4:30 P.M. every 15 minutes and the composite samples analyzed for suspended solids. Settleable solids were also obtained from grab samples each morning and afternoon.

At the same time there were installed two sets of two-stage digestion tanks. Both sets consisted of a 470 gallon primary and 470 gallon secondary tank.

The No. 1 set of tanks had fixed covers, the primary containing a central heating coil and central stirring mechanism. The secondary was neither stirred nor heated.

The No. 2 set of tanks had floating covers on both primary and secondary. The primary was heated with a peripheral heating coil and was not stirred.

The secondary of this No. 2 system was also unheated and unstirred.

Gas was collected in domes on the covers of all tanks and piped to separate gas meters, one meter for each individual tank.

Means was provided for transferring sludge from both primary tanks to their secondary tanks from which secondary supernatant could be drawn off at any level in the secondary or sludge removed from the bottom. The No. 2 primary which was not stirred was also equipped with a supernatant draw off pipe which was adjustable so the supernatant could be removed from any elevation in this primary tank.

Both the clarifiers and the digesters were operated simultaneously and the laboratory work carried on at the same time, but in order not to confuse the results they will be presented herewith separately.

Conclusions

The results obtained from the operation of this experimental plant indicated that the theoretical data originally adopted in the proposed Hyperion plant design were too liberal with regard to several of the units and therefore the comparatively small cost of operating this plant over the 20 months period it was in service will result in a saving of at least several hundred thousand dollars in the construction of the new Hyperion plant and the design may be accomplished with a considerably greater degree of confidence than would otherwise have been the case.

The Hyperion sewage is well adapted to physical and chemical flocculation prior to sedimentation and one hour detention in the clarifier is ample.

The Hyperion sludge is satisfactorily digested in two stage digesters with continuous sludge mixing in the primary stage with either mesophilic or thermophylic digestion with loadings as follows:

Mesophilic Digestion . . 85° F.—12#} Pounds of dry solids per cu. ft. of
Thermophilic " . . 130° F.—22#} primary digester capacity per mo.

Elutriation, at least in connection with mesophylic digested sludge, indicated a very appreciable saving in chemicals in conditioning the sludge for filtering and is deemed essential for Hyperion sludge.

By the use of elutriation the following yields are anticipated with the indicated percentage of $FeCl_3$ from vacuum filters:

2.5% $FeCl_3$—1.65 Pounds dry solids per sq. ft. per hour
5.5% " —5.95 " " " " " " " "

Clarification

Clarification was started July 20, 1938.

The indicated percentages of removal apply to the reduction in amount of suspended solids determined from duplicate samples taken from the composite of the influent and effluents of the clarifiers every 15 minutes from 8 A.M. to 4:30 P.M. "Standard Methods" was not followed for determining suspended solids but rather the aluminum cup method using Celite wherein the filtered quantity was 1 liter. With chain-o-matic balances reading to one-ten thousandth of a gram, and using one liter samples, the amount of suspended solids were carried to one-tenth of one part per million.

Figure 2 shows the suspended solids in the influent and effluent and the percentage of removal by days from July, 1938, to December, 1939.

Twenty-one different conditions of clarification were tried for not less than five days. The averages for each condition were as follows:—

No. of Days	*Condition*	*Influent*	*Average Effluent*	*% Removal*
101	Plain Sedimentation—2 hr. ret.	286.00	91.00	68.18
51	30 min. flocculation—2 hr. sed.	275.07	63.78	76.81
30	30 min. flocculation—1 hr. sed.	263.48	66.66	74.70
17	30 min. flocculation— 2 hr. sed. 3 ppm $FeCl_3$	319.0	43.7	86.3
7	30 min. flocculation— 2 hr. sed. 4 ppm $FeCl_3$	328.3	37.6	88.55
6	30 min. flocculation— 2 hr. sed. 7 ppm $FeCl_3$	297.0	34.6	88.35
10	30 min. flocculation— 9 ppm $FeCl_3$ 2 hr. sed.	299.6	33.6	88.79
7	30 min. flocculation— 2 hr. sed. 54 ppm Act. Alum.	336.1	42.4	87.38
7	30 min. flocculation— 2 hr. sed. 63 ppm Act. Alum.	257.8	41.6	83.86
6	30 min. flocculation— 2 hr. sed. 70 ppm Act. Alum.	212.3	24.6	88.41
7	30 min. flocculation— 2 hr. sed. 100 ppm Act. Alum.	254.6	32.0	87.43
5	30 min. flocculation— 2 hr. sed. 50 ppm Lime	265.3	52.3	80.29
5	30 min. flocculation— 2 hr. sed. 100 ppm Lime	280.8	41.5	85.22
	2 Stage—no primary flocculation: 50 min. retention in each clarifier—12½ min. in sec. flocculator.			
6	No Sludge returned	236.0	70.0	70.34
6	Secondary Sludge returned	251.0	83.0	66.93
6	2.59 ppm $FeCl_3$ added to Sec. Floc.-Sec. Sludge returned	250.5	71.0	71.66
5	5 ppm $FeCl_3$ added to Sec. Floc.-Sec. Sludge returned	265.4	67.6	74.53
	Two-stage with Primary and Secondary Flocculation 50 min. retention each Clarifier and 12½ min. in each Flocculator			
6	No sludge returned	238.0	79.5	66.60
6	Secondary Sludge returned	267.0	70.0	73.78
6	2.5 ppm $FeCl_3$ added to Sec. Sec. Sludge returned	251.3	59.3	76.40
6	5 ppm $FeCl_3$ added to Sec. Sec. Sludge returned	206.6	35.7	82.72

Figure 3 shows these averages graphically.

In order to correlate the results obtained during the day with results that would have been obtained on a 24-hour basis samples were taken for nine days on a 24-hour basis and the average percentages of removals were as follows:

8 A.M. to 4 P.M. Av. Floc.—2-hr. Clarif., 74.9% Floc.—1-hr. Clarif. 77.2%
24-hour Average Floc.—2-hr. Clarif. . 72.8% Floc.—1-hr. Clarif. 72.4%

Attention is called to the results obtained from 30-minute flocculation and 2-hour clarification which have been averaged for 51 days. Between July 20 and August 19, 1938, there were 20 days and between September 6 and December 21, 1939, there were 31 days. The average results from these two periods are very interesting.

	Influent	Effluent	% Removal
20 days, Summer 1938	293.0	54.9	81.3
31 days, Winter 1939	263.5	70.9	73.1

Therefore in the summer with the strongest sewage, the effluent was actually better than it was in the winter with weaker sewage.

Digestion

The two sets of two-stage digestion tanks are identical in size and were loaded with identical sludges. The same temperature was maintained in the primary of each. In the No. 1 primary there was a central stirring mechanism so that the contents of the tank was uniform throughout. On making additions to this primary, the overflow to the secondary was automatic and represented the contents of the tank. In the No. 2 primary there was no stirring and it was necessary to withdraw supernatant liquor from the tank as long as it was reasonably clear because if the transfer was made automatically from the bottom to the secondary, the primary was soon depleted of seed sludge. No experiments were made where seed sludge was added to the primary with the raw sludge.

The No. 2 tanks had floating covers, the No. 1 tanks having fixed covers. This reduced the capacity of the No. 2 tanks slightly below that of the No. 1s.

The tanks were seeded with sludge from Terminal Island in July, 1938, and the primaries operated at 85° F.

The quantity added daily was measured in four-gallon buckets which, with the transfer and secondary supernatant or sludge, was sampled and run for moisture, volatiles and ash. The daily gas production from each tank was measured in standard gas meters.

The loadings on the digesters were increased from time to time in order to determine the maximum loadings with accompanying gas production and decrease in volatiles.

Table I gives the monthly loadings and results for both sets of digesters.

In the No. 2 digester (without mixing) foaming developed in January, 1939. This tank was rested and the loading decreased before further increases. In April, 1939, it again foamed and again in June, 1939.

Figure IV shows the daily loadings in pounds of dry solids and the gas produced in cubic feet.

Figure V shows, on half-month averages, the loading in pounds of dry solids per cu. ft. of primary digester capacity per month, the quantity of gas produced per cu. ft. of dry solids added to the digester, and the percentage of reduction in volatiles.

The No. 1 digester with mixing was operated until August, 1939, at 85° F. when foaming developed. From November, 1939, to February, 1940, this digester was operated under thermophilic conditions at 130° F. No foaming occurred at any time at this temperature even with a retention period of 2¾ days in the primary, although at this loading there was not sufficient digestion in the primary so that too much of a load was imposed on the secondary.

Figure VI shows the daily loadings in pounds of dry solids and the daily gas production in cu. ft.

Figure VII shows the half-month averages of:

(a) loadings in lbs. of dry solids per cu. ft. per mo.
(b) cu. ft. of gas per lb. of dry solids added.
(c) per cent reduction in volatiles.

The sludge produced at the maximum loadings drained and dried satisfactorily on sand beds and could be filtered in the laboratory using Genter's Buchner funnel method (1) or a 1/10 of a sq. ft. cylindrical filter. The sludge had only a very slight sewage odor.

From these experiments I believe it is safe to use the following loadings when the primary digester has mixing:

Mesophilic Digestion at 85°F-12#/cu. ft./mo. with not less than 55% reduction in volatiles and produce 7 cu. ft. of gas per lb. of dry solids.

Thermophilic Digestion at 130° F.-22#/cu. ft./mo. with 50% reduction in volatiles and produce 6 cu. ft. of gas per lb. of dry solids.

Filtration and Elutriation

On November 22, 1938, we received from the Oliver Filter Corporation in Oakland the equipment necessary to install and operate a vacuum filter of 3 ft. dia. by 1 ft. wide. This equipment was installed on a wooden platform adjacent to the experimental plant and consisted of an agitator drive, a variable speed drum drive, a filtrate receiver, a vacuum pump and electric control panel, in addition to the filter unit.

The digested sludge from the secondary digesters was placed in conditioning barrels where various percentages of Ferric Chloride and Lime or Ferric Chloride alone was added, based on the amount of dry material in the sludge. With these varying percentages of conditioning chemicals, various operating conditions of the filter were used to determine the quantity of dry solids which would be produced per hour per square foot of filter area.

Between December 9, 1938, and February 24, 1939, 29 experimental runs were made with sludge as it came from the digesters either with or without decanting off free water.

Between February 24, 1939, and March 20, 1939, a larger tank with draw-off cocks spaced on the outside and equipped with a picket fence thickener was installed for the elutriation of the digested sludge prior to its conditioning for filtering. This elutriation consists of washing the sludge with several volumes of effluent or tap water in order to remove by dilution the ammonia compounds present in the sludge, that increase the amount of conditioning chemicals required for filtering.

From March 29, 1939, to June 26, 1939, 57 runs were made on elutri-

ated sludges and 14 runs on identical sludges without elutriation, with various percentages of conditioning chemicals and various operating conditions of the filter. Various rations of wash water were also used.

For each of these runs a laboratory analysis was made to determine the percentage of moisture of the digested sludge to be filtered and of the filter cake as it came from the filter. Many determinations were also made of the quantity of suspended solids in the filtrate.

Table II gives in detail the data on each run.

Figure VIII shows the yield in lbs. of dry solids per sq. ft. per hour for each filter run made between March 20 and June 21, 1939, for the varying percentages of equivalent $FeCl_3$. Equivalent $FeCl_3$ is used because without elutriation better results were obtained using lime with $FeCl_3$, and this lime is included in this tabulation as equivalent $FeCl_3$ based on cost of the two materials. In the yield, however, where lime was used, the weight of the $CaCo_3$ which was precipitated by the addition of the lime was deducted from the indicated yield in order to be on the same basis as the other runs.

The filter runs made between December 9 and February 24 are not shown because the results were so variable as to indicate the presence of large percentages of dead seed sludge.

For Hyperion sludge, elutriation is deemed essential in connection with sludge conditioning and the following yields are anticipated with the indicated percentage of $FeCl_3$:

2.5% $FeCl_3$—1.65# dry solids per sq. ft. per hour.
5.5% $FeCl_3$—5.95# dry solids per sq. ft. per hour.

This experimental work was done under the jurisdiction of the Board of Public Works of the City of Los Angeles, Lloyd Aldrich, City Engineer; and under the direct supervision of H. G. Smith, Engineer of Sewer and Plant Design and Operation, with E. G. Studley, Supervisor, in charge of operations at the plant.

REFERENCES: (1) A. L. Genter—"Absorption and Flocculation as Applied to Sewage Sludges." Sewage Works Journal, Vol. VI, No. 44 (July, 1934.)

NOTE:—Table and figure references as used with original presentation of paper.

THE CARE OF MOTOR BEARINGS

By L. M. BEST

Engineering Dept., General Electric Co.

Since there are many types of motors and bearings, this discussion will be confined to oil ring lubricated sleeve bearings and ball bearings, such as are used in standard horizontal motors. This selection eliminates bearings of the oilless type, pressure fed type and waste packed type. It eliminates bearings for vertical motors and horizontal motors that have special bearing housing construction. There are three purposes to be accomplished to give proper care to any motor bearing.

1. Systematic maintenance to insure against bearing failure.
2. Correct analysis and determination of the cause of any bearing failure.
3. Intelligent selection and installation of new bearings to prevent repetition of failures.

SLEEVE BEARINGS—OIL RING LUBRICATED TYPE

1. Maintenance

Nearly everyone who has had experience with machinery has a general idea of the maintenance of this type of bearing. The frequency of inspections and adding of oil depends entirely upon the application and in general, it can be said that regular inspections should be every week to every month and should not require oil oftener than once a month.

When a sleeve bearing wears too far or fails completely, there may be expensive damage, to the shaft as well as electrical windings of the rotor and stator, in addition to the loss of money and time in production. To avoid these losses, be SYSTEMATIC in your maintenance and inspections even to the point of keeping a written log recording dates of inspections and conditions that do not seem normal. Failure to record time, leaves maintenance to the memory which too often remembers too late. Record motor air gaps and bearing clearances so that wear can be detected and bearings replaced in time.

Let CLEANLINESS become a habit. At every inspection, see that there is clean oil in the bearings and wipe the outside housing clean. On a clean motor, oil leakage can be easily detected. An important benefit derived from keeping the housing clean is to prevent oil drops or vapor being drawn into the motor winding by the normal air circulation within the motor. Oil on the electrical windings collects dirt and is an invitation to electrical trouble. Most insulation varnishes up to a few years ago were soluble in oil so the presence of oil greatly reduces the life of the electrical winding.

Oil should be MAINTAINED at the proper level as indicated by the oil gauge or if no level is indicated refer to the manufacturer for the recommended level. Oil should be changed completely at regular intervals to flush out any accumulated abrasive or corrosive elements. Oil rings should be inspected to see that they rotate freely. Bearing temperatures should be noted particularly since excessive temperature is a warning of difficulty.

We are often asked what oil should be used in sleeve bearings. The

motor sizes selected for this discussion and manufactured by the General Electric Co. have in nearly every case, steel shell, centrifugally cast babbitt linings. They are designed to operate at approximately the same pounds per square inch pressure, providing ample safety factors in pressure and operating temperature. At normal ambient temperature our bearings will operate at 60 degrees C. or below. We therefore make it possible for you to use one oil in all motors. There are many oils on the market making it impossible for us to test them all. Our knowledge of lubrication and lubricants is yet in such a state that suitable oils cannot be produced on specifications alone. We therefore recommend that you rely upon the advice obtained from responsible oil companies or testing laboratories for the selection of your oils.

In testing oils there are a number of data recorded such as specific gravity, viscosity, flash point, color, carbon residue, acid or sulphur, etc. There are differences such as Eastern, Western, Midcontinent and blended oils. Assuming satisfactory characteristics in other respects, the one factor which to a greater extent than any other, determines the suitability of an oil for motor bearings, is its viscosity. It is the measure of the body or internal friction of an oil at a specified temperature. Two methods most frequently used to specify viscosity are: First, Saybolt method; second, SAE numbers. Saybolt is a measurement of oil in time (seconds) at a constant oil temperature. SAE numbers refer to automobile and internal combustion engine oils whose viscosity and other characteristics conform to standards adopted by the Society of Automotive Engineers. Many automotive type oils are suitable for electric motors, however, industrial oils known as Turbine and Motor-Dynamo oils are to be preferred. In Southern California where we do not encounter severe cold, Saybolt viscosities of 200 to 300 seconds at 104 degrees F. give good results.

For good maintenance, belt tensions should be carefully watched as nearly all types of belts stretch and shrink with climatic conditions and wear. Do not permit excessive pressures from belts, chains, gears or misalignment. See that the rotor floats freely, then you know there are no thrusts on the end of the bearings.

2. Analysis of Bearing Failures

Poor installation might be a cause, such as misalignment of motor with its connected load, or excessive belt tensions or gear thrust at the time of installation. In this case, failure would no doubt occur immediately after installation.

Lack of maintenance might be a cause, such as lack of lubrication, where the oil has leaked out or never was put into the bearing. There may have been too much dirt or too much side thrust caused by belts, chains or gears.

The cause may be found in the application, such as atmosphere laden with excessive moisture, chemicals, or dirt. End thrusts may have been created by worn flexible couplings, blowers, pumps, or equipment operated at an angle off level. Bearings are sometimes hammered out by severe vibration caused by unbalanced pulleys, blower wheels or vibration from shaker screens or reciprocating machines.

A failure may be traced to wrong or inferior lubricant. Due to the temperature in which the motor operates, an oil may have been used that was too light or too heavy. The oil may have turned acid, sludged or carbonized.

The failure may have been due to a defective or inferior bearing. It may have been fitted too tight or too loose on the shaft. There may have been misalignment within the motor as distinguished from misalignment of motor with its load. Inferior babbitt, improper fits and grooving are possible but not likely with present-day manufacture.

3. Selection and Installation of New Bearings

In the selection of a new bearing, it is usually more economical to purchase new bearings from the motor manufacturer. This assures you of low cost and proper dimensions and grooving. Before a new bearing is installed, the shaft journal must be measured to see that it is up to size and if too small, it must be built up to size. The shaft must be smooth and polished. Occasionally it is necessary to rebabbitt a bearing locally. This must be done intelligently with proper technique in pouring the babbitt, machining to exact fits and proper grooving. It will save you money and time if you carry replacement bearings in your stock or make sure that the bearings you might require are regularly carried in the manufacturer's local stock and can be secured at any time.

Whenever there is a failure of a sleeve bearing, it is always possible and even probable that the rotor has rubbed the stator. The frictional heat created by rubbing may cause the wedges and motor insulation to burn at the point of rubbing. Your motor should therefore be completely disassembled, carefully inspected and if the wedges or insulation are charred or burned, they should be repaired by a competent electrician. If the windings are not burned, it is advisable that while the motor is disassembled, you clean, then paint the windings with a good insulating varnish such as General Electric #1201 red Glyptal. These small considerations of electrical winding maintenance at the time of motor bearing maintenance will assure you of longer motor performance and economy.

BALL BEARINGS—GREASE LUBRICATED

1. Maintenance

Ball-bearings, like sleeve bearings require systematic inspection and maintenance. We have distributed a publication entitled "How to Grease Ball-Bearing Motors by means of the G-E Pressure-Relief System." If you do not have a copy, you may secure one from your nearest General Electric office by writing for GES-1476 and it will be mailed to you.

This publication tells when a General Electric motor bearing has sufficient lubrication, how to add additional lubricant, how to purge the bearing cartridge housing of the old grease, with new grease. This publication also clearly shows the General Electric ball-bearing housing construction on several different types of motors and gives the requirements of a satisfactory type of grease.

Since approximately 80% of all ball-bearing failures are caused by dirt, you will find that the General Electric Co. has gone a long way in eliminating the possibilities of getting dirt into the ball bearings. The first forward step was the adoption of the cartridge type bearing housing. This permits complete disassembly of the motor, yet leaves the ball bearings completely housed in their cartridges so that the process of assembling or disassembling the motor does not permit dirt to fall into the bearing. When bearing

cartridges are not used, difficulties of assembly are usually encountered and the bearings are exposed to dirt when the motor is disassembled. Prior to adoption of the pressure relief system of greasing, the General Electric Co. recommended disassembling the bearing cartridge and thoroughly washing the bearing and housing approximately once every year; then repacking the bearing and cartridge with definite amounts of grease. This recommendation was abandoned for the new pressure relief system on all G-E motors where it can be applied. To my mind, the pressure relief system of lubrication is the greatest step forward in the elimination of dirt which, as I have already stated, is the cause of approximately 80% of all ball bearing failures.

An important contribution brought by the pressure relief system is the purging action whereby grease is forced into the beater action of the ball-bearing and the mixture is expelled out of the relief. Frequent purging by this means results in clean grease in the bearing the same as an oil filter will keep oil clean in an automobile engine.

Other practical features of the pressure relief system are: A motor can and must be lubricated while the motor is running. The grease may be fed to the bearing by a hand operated grease gun which feeds the grease slowly and in small amounts. The relief plug must be removed from the bearing in order to prevent building up a pressure in the bearing housing, as pressure will force grease along the shaft into the motor. The General Electric location of the relief plug is an excellent one because it creates the least amount of back pressure and does not allow any grease to flow along the shaft into the motor.

When bearings are washed, often dirty containers and dirty cleaning solvents are used. After twelve years of experience, I have definitely concluded that ball-bearings are never washed clean; when once dirty, they are always dirty in spite of a washing. Further, when money is spent on labor and material to clean a bearing, there is left only a "used bearing" which is still probably dirty. I feel it is far more economical to install a new bearing than to attempt to clean an old bearing.

2. Analysis of Ball-Bearing Failures

Ball-bearings roll on a metal-to-metal contact and from the laws of metal fatigue, the life of a ball-bearing is definitely limited, depending on the load or pressure between balls and races and on the number of revolutions or speed. Hence, many failures are only normal replacements.

Failures may be due to faulty motor installation such as excessive belt tension, gear thrust, or having been started without lubricant. Lack of maintenance such as too much grease, not enough grease, dirt or excessive side pull from belts. The application may cause bearing failures such as being flooded or operated in the presence of excessive moisture, chemical fumes or dust. Excessive thrusts from worn flexible couplings, blowers, pumps or gears may be the cause. Bearings may rotate in housings due to excessive vibration caused by shaker screens, ball mills, unbalanced pulleys or fans. The ambient temperature may be too hot causing the grease to melt and run out or the ambient may be too cold causing the bearing to rotate in its housing.

The bearing may have failed due to the type of lubricant used. The grease may have been too acid, it may have oxidized, oil may have separated from the soap base, it may set too hard at the lowest cold temperature, or

may melt at the highest operating temperature. I might mention, that usually ball-bearing greases for normal application are known as soda-base greases. This type of grease will readily emulsify in water and is therefore not suitable if it is at all possible for moisture to enter a motor bearing. This condition, however, is very remote because the motor windings themselves must be kept reasonably dry and following that particular precaution means that the bearings are usually dry enough to use soda-base greases.

Another group of greases is known as calcium-base greases which are not soluble in water but have other characteristics that are not desirable in ball-bearings.

Still another group of greases is the high pressure greases usually used on the automobile chassis. These are usually metallic base greases such as aluminum, lead, etc. These greases are not suitable for electric motor bearings.

In a ball or roller bearing, no lubrication is needed between the rolling surfaces. However, between the separator and the ball-bearing, we have frictional sliding contacts the same as we have in a sleeve bearing and it is these surfaces which require lubrication. It is the oil in the lubricant that furnishes the lubrication and the reason that motor manufacturers ordinarily do not use oil is the fact that a ball-bearing acts as a beater and would whip any oil into a foam or mist, which would be practically impossible to hold in a bearing housing. Grease lubrication, therefore, is a compromise whereby we are able to manufacture bearing housings which will not permit leakage of the lubricant, and manufacture these housings at a reasonable cost. We give you motors with grease lubrication that operate as successfully as oil lubricated bearings up to certain horsepower and speed sizes. However, in large size motors, the bearing heat must be dissipated and we find that by circulating cool oil through a bearing, the oil performs two functions, one of lubricating and second, cooling. Greater cooling possibilities are had with oil in the large size motors and vertical motors, than with grease.

Again, the choice of the grease we leave entirely to the recommendations of the lubricating specialists of responsible oil companies. I am sure that you are well aware of the fact that there are greater differences in greases offered on the market than there are differences in oil. This naturally is due to the fact that all of the different types of oils may be compounded with different types of soap or other forms of bases producing many kinds of grease. It is impossible for our Company to maintain a testing laboratory to keep a close check on all greases manufactured and thus give recommendations. In our experience, however, we have developed a grease which we know will do your job in all of the ordinary applications, and most special applications. This grease has proven to us that it gives satisfaction on nearly all applications down to a minus 20 degrees F. ambient to a 225 degrees F. ambient. It has been used with success on motors of railways, street cars, steel mills, industrial plants, high speed pumping motors, electric shovels, and other applications too numerous to mention. A grease, the same as an oil, cannot be manufactured by merely submitting specifications. From our experience with the General Electric ball-bearing grease, we believe it to be the best grease for the purpose and we recommend that you use General Electric ball-bearing grease for ball-bearing motors in normal service.

Failure may be because a bearing may have had a defective retainer or defective steel in the balls or raceways. I will assure you that those of us

who have had considerable experience with ball and roller bearings, know that many ball-bearing failures appear to many people to be defective steel. In most cases, however, chipped, cracked and broken balls and raceways are due to dirt, excessive load, or improper fits to the bearing on the shaft or in the housing. Ball-bearing failures have been studied, photographed and catalogued almost like finger prints and in many cases, we are able to tell the cause of failure by analyzing the failed ball-bearing. To the disappointment of many people, our analysis brings a report that the bearings failed because of dirt. This is not purposely done with an intention to shirk responsibility of a failed bearing but as stated before, almost 80% of the failures are due to dirt. This has been proven conclusively by the telltale damage in a bearing.

3. Selection and Installation of New Bearings

If the bearings have rotated in the housing or on the shaft, the worn metal must be replaced before a bearing can be installed with the proper fit. The selection of the new bearing to replace a failed one must be done intelligently. Ball-bearing manufacturers have many bearings which are interchangeable dimensionally. However, the numbers used by the various ball-bearing manufacturers are not thoroughly standardized and consequently, a number taken from a bearing of one bearing manufacturer and ordered on another bearing manufacturer might give you a bearing of an entirely different type and one which is not suitable in your motor. Let me outline some of the different types of bearings as manufactured by all ball-bearing manufacturers.

First, the Conrad or commonly known single-row deep-groove bearing. This type of bearing has the least number of balls running in deep grooves on both the outer and inner races. This type is usually considered the quietest type because it has the least number of balls and will take the greatest end thrust in both directions because of the deep grooves.

The next type of bearing is the Maximum Load, or notched type. This bearing is similar to the Conrad type except that there are two notches to make a hole where more balls can be squeezed into this type bearing. Here the radial load is carried on a greater number of balls and consequently, it is called the Maximum Load type. Due to the notches, however, this bearing is not capable of taking as high an end thrust as the Conrad bearing.

Another type of ball bearing is the Counter Bore single-row radial bearing. This bearing has a very thick edge on one side of the outer race and a very thin edge on the other side of the outer race. In other words, it is in appearance like a thrust bearing and differs only from what is known as an angular contact thrust bearing by the way the bearing is ground and preloaded. This bearing will take an exceptionally large thrust in one direction, as well as the pure radial load. In the opposite direction, however, it is not capable of taking end thrust.

A fourth type of bearing is the double-row self-aligning bearing, where the inner race has two grooves. There are two rows of ball-bearings, and the outer race has only one groove of a very large radius which permits the outer race to be misaligned considerably before developing any excessive internal friction. This type of bearing is not capable of taking end thrust in either direction.

From these fundamental principles you can see that the different types of

bearings should not be interchanged one for the other, unless your application or operating conditions warrant it. These various types of bearings may have many modifications such as a shield on one side, a shield on both sides with the bearing lubricated by the bearing manufacturer. There may be other modifications, and to describe them all would make this discussion too lengthy. I again caution you to make all replacements with the same type of bearing. It is usually best to purchase your bearings through the motor manufacturer for the following reasons:

Ball-bearings may have the same appearance; however, various applications require ball-bearings with different internal fits. Some motors have the inner races locked on with lock nuts. Other motors have the bearings pressed onto the shaft without any lock nuts. Motors designed for electric railways and street cars, take into consideration severe vibration and tighter press fits are used on the shaft as compared with motors for ordinary industrial purposes. Likewise, ball-bearings manufactured for automobiles and farm machinery usually require lighter press fits onto the shaft and into the housing. Only the motor manufacturer knows the type of fit used in their motors and therefore they can best select the ball-bearing which should be used on their motors. If you are having repeated failures on bearings, part of your failures may have been due to using bearings of the wrong internal fit.

I trust that I have pointed out enough items to show that the care of your motor bearings should be left in the hands of a man with considerable experience and that the care of bearings in the broad sense, including the analyzing of the failure and replacing of the failed bearings, should certainly not be left entirely in the hands of the ordinary grease monkey and sledge hammer mechanic. The General Electric Co. is always happy to discuss your bearing problems and assist you with the experience of their engineers and the services of their service shops, which are located in twenty major cities throughout the United States.

NOTES

By the Secretary

At the Catalina Meeting the General Electric Company furnished us with some fine entertainment Sunday evening. Two films were shown. One, "A Trip Through A Modern Electric Manufacturing Plant," surely must have been an eye-opener. The intricacies of machinery, the coordination of work, and the vast amount of research work necessary to produce the finished product are interesting. The other film, "The Columbus Sewage Treatment Plant" (in color) was very good. It must be admitted that the film had a copious supply of switch panels inside and out, but, why not? It was taken primarily for that purpose. The film offered one outstanding feature: Those present were impressed with the ivory paints on all panel work in the entire plant. Needless to say, the plant had that dressed up appearance and served as an example of what good housekeeping will do for a sewage plant. Our thanks are expressed, herein, to the General Electric Company for its courtesy in showing these films.

Incidentally, Bill Kyte, of this company, is one of our newest members.

Speaking of new members, we have had a number of new ones this year. Here they are:

R. W. Borough	Lynn Thatcher	B. J. McMorrow
Paul Clements	R. W. Lefever	James Carey
Sam Soroker	H. Ross Onley	G. R. Best
Alvin Appel	S. C. Swanson	Clarke Chapman
F. M. Darnell	Lloyd Aldrich	Ludwig Huebner
Uno Erickson	Charles Towers	Robert G. Harding
Walter J. Walker	C. J. Ullrich	H. W. Davey
John W. McDuell	Elmer B. Belt	John Casey
Ralph Lund	Edward Strangard	R. W. White
Charles Baugh	Eugene Ceriat	L. S. Curfew
Hugh MacDonald	J. R. Lester Boyle	F. B. Fulmer

If you want to know more about these men look in the roster at the end of the book.

Oh yes, Bob Harding made the trip out from Salt Lake to attend the meeting, and Phil Martin came over from Tucson. We feel honored that you gentlemen made the trip and sincerely hope it was worth your while.

The unsung hero at the Catalina meeting was Alvin Appel. He handled the registration in fine style, even though he had to ride herd on the gang until Monday noon to get it completed.

The New York State Sewage Works Association held its Spring meeting June 20, 21, and 22 at Syracuse, New York. There were some papers given there that you should look forward to in the Sewage Works Journal.

The Pennsylvania Association also held a meeting in June at the Pennsylvania State College. It is interesting to note that its program has, as so many of the current programs have, some phase of plant safety or human protection offered in the form of a paper.

The Schools Committee of the California Sewage Works Association and the California Section of the American Water Works Association is holding a number of regional conferences in the Northern part of California this year. Those who have attended the first meetings appear to be rather enthusiastic about them.

Two of our Board of Directors, Alec Bell, our genial past president, and J. F. Byxbee, have been on the sick list. We wish them a speedy recovery.

Al Castro, at Santa Clara, has made himself an electric turbidometer. He hasn't, as yet, established any correlation between the turbidity readings and other plant data, but he hopes to do so soon. Go to it Al, intelligent initiative on the part of the plant operators is to be commended.

The stories told by Phelps, Brown, Bowlus, and Hoskinson, of diamond rings and similar things, raises the question of whether it might not prove profitable for a number of cities to drag the sewers and put in fine screens to catch the valuables.



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BIOFILTRATION AT PETALUMA



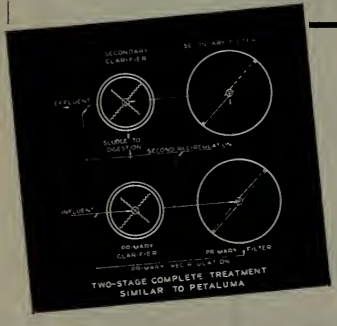
Left: Biofiltration System at Petaluma, Calif.

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- Shallow filters—3 ft. media depths
- Installed costs 25 to 35 percent less
- Operating costs 30 to 40 percent less

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Dosing Rate Raw—M.G.A.D.	5.05	10.6
Total—M.G.A.D.	17.2	37.1
Sus. Solids—PPM		
Raw	424	462
Final	33	43
Removal—percent	92.3	90.7
B.O.D.'s—PPM		
Raw	576	521
Final	14	28
Removal—percent	97.6	94.6
Raw B.O.D. Loading Lbs/cu yd/day	2.47	4.78



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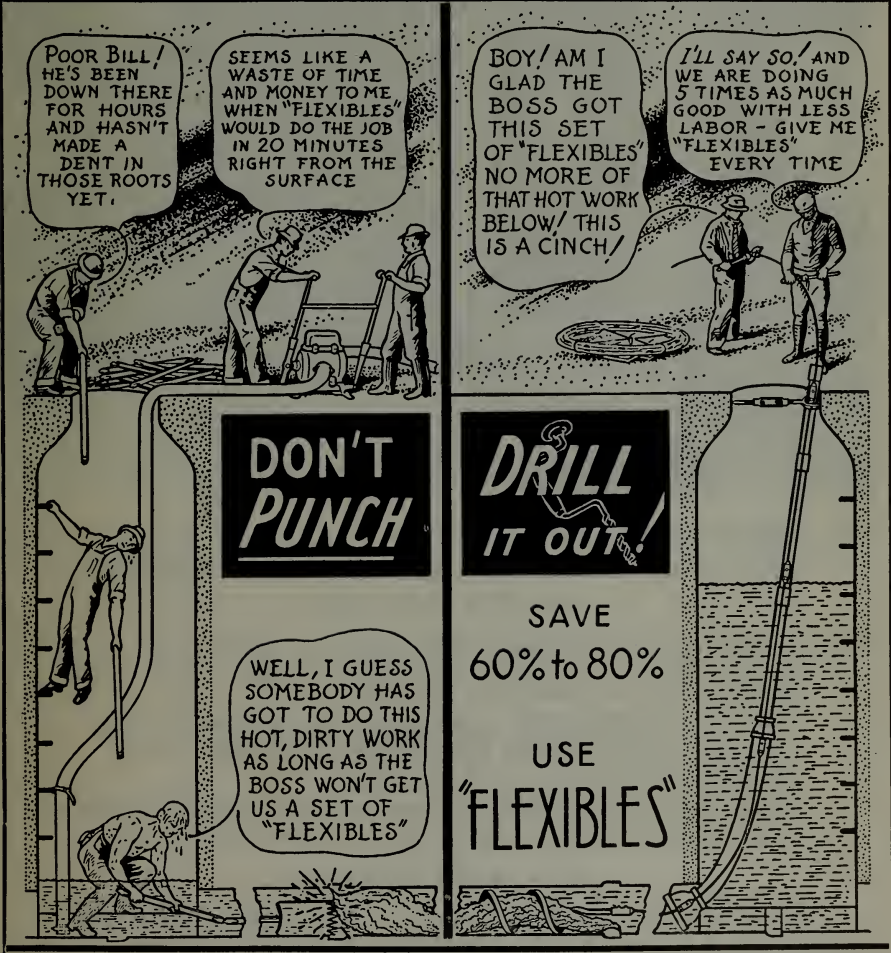
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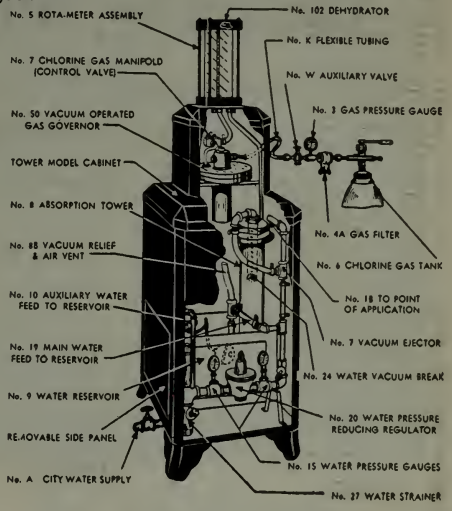
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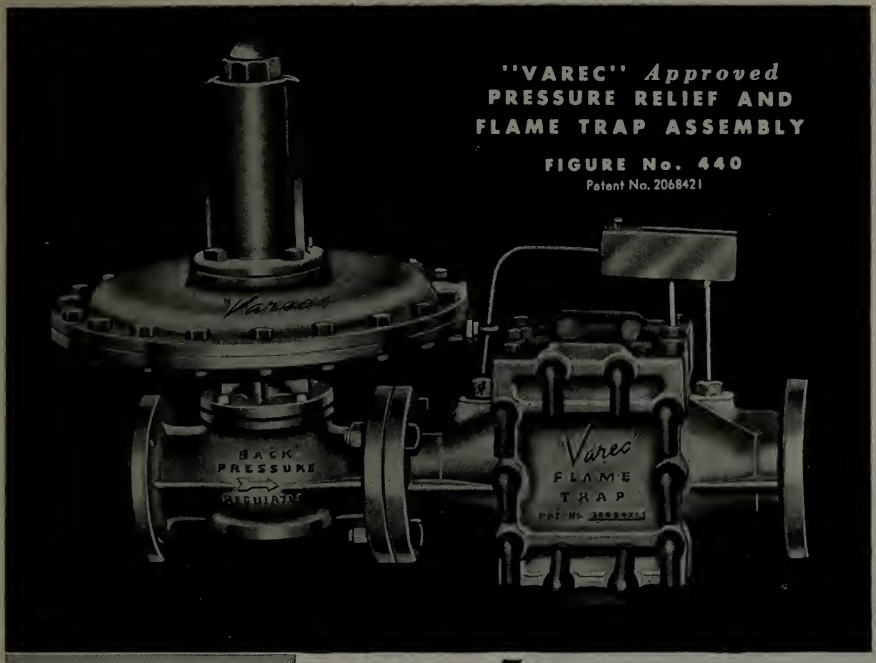
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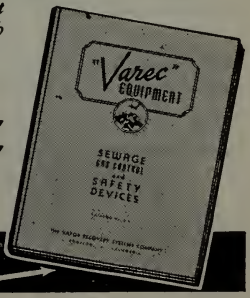
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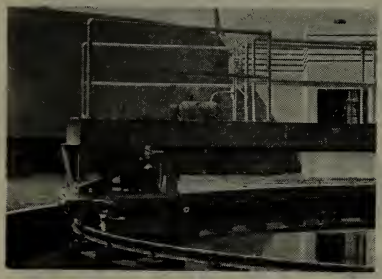
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RIGHT: Sewage Works, Sonoma State Home. Note final Dorr Clarifier with circular Automatic Magnetite Filter around periphery.



BELOW: Close-up of the revolving cleaner element of the Automatic Magnetite Filter.



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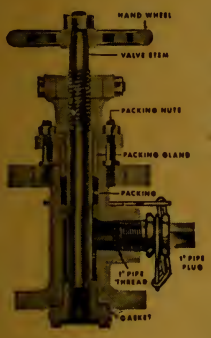
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